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Investigation into air launch cruise missile (ALCM) flight information loading

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NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

INVESTIGATION INTO AIR LAUNCH CRUISE MISSILE (ALCM)
FLIGHT INFORMATION LOADING & DISPLAY TECHNIQUES
DURING FLEX TARGETING PROCEDURE

by

John Charles Ruess

March 1982

Thesis Advisor: W. Moroney

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Investigation into Air Launch Cruise Missile (ALCM) Flight Information Loading & Display Techniques During Flex Targeting Procedure

by

John Charles Ruess
Captain, United States Air Force
B.S., Loyola University of Los Angeles, 1974

Submitted in partial fulfillment of the
requirements for the degree of

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ABSTRACT

This thesis compared the use of a discrete utterance voice recognition system and a keyboard entry device in retargeting Air Launch Cruise Missiles (ALCM) prior to launch from a B-52G aircraft. Time to load, input and output accuracies, and time versus accuracy measurements were made for each of twenty subjects. Keyboard entry was found to be better than voice entry in time to load and input accuracy. These findings are limited to discrete utterance voice recognition systems and most probably would have been different if a connected speech recognition system had been utilized.

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I. BACKGROUND

A. INTRODUCTION

The B-52G was selected in 1977 to be outfitted with an all new navigation and weapons control suite called the Offensive Avionics System (OAS). This system would control and launch the Air Launch Cruise Missile (ALCM). The flight crews based at the Boeing Airplane Company, Wichita, Kansas, and the human factors staff at Edwards AFB, California, were tasked to evaluate the OAS. Based on conversations with these two groups, it was discovered that the ALCM retargeting procedure, also known as "flex targeting", was slow and cumbersome.

The purpose of flex targeting is to give political and military leaders greater flexibility during both strategic and tactical conflicts. In future warfare, the political as well as the military situation will be in constant flux. As the situation rapidly changes, targets will change as well. A commander's ability to change the course of a battle in minutes or seconds will be dependent upon the ability of his forces to respond to these sudden changes. This flexibility depends upon rapid weapon retargeting which the present OAS does not provide.

One possible solution to this problem was seen in computer voice technology. Work in this area of computer

voice applications research is ongoing here at the Naval Postgraduate School by Dr. Gary Poock. If was felt that the ALCM flex targeting problem could be easily investigated here due to the extensive facilities of the Human Factors Laboratory.

B. OAS/ALCM SYSTEM IN B-52G

1. Background

The B-52 bomber has been in the U.S. Air Force arsenal since 1954. Seven hundred forty-four aircraft were produced through 1962 beginning with model "A" and finishing with model "H". Today only three models, the "D", "G", and "H" remain in service.

All three are assigned nuclear and conventional roles. The "D" model, the oldest and least modified of the three, is expected to be retired within the next two years and be replaced by 100 B-1B aircraft. (The USAF has designated the cruise-missile-capable B-1 the 'B-1B'. It will be equipped with external cruise missile pylons.)

The "G" and "H" models continue on active duty and are the subjects of many modifications to extend their life, improve their survivability, and add to the missions they are already expected to perform. This paper addresses a mission added recently to the B-52G, which is presently undergoing modifications which will allow it to carry the Air Launched Cruise Missile (ALCM).

2. Operation

The ALCM is a small, unmanned, winged air vehicle capable of sustained subsonic flight following launch from the B-52G (see Figure 1). Propelled by a turbofan engine, it incorporates a nuclear warhead with a variable yield of up to 200 kilotons for a "hard target" kill capability, and is programmed to strike a pre-determined surface target [Ref. 1].

While the ALCM is onboard the B-52G, it is receiving position, heading, and altitude information from the aircraft's inertial navigation system every 60 seconds [Ref. 2]. When the missile is activated for launch, it knows where it is and where it is heading.

Upon launch from the B-52G, ALCM wing deployment is attained within two seconds, and engine start within three seconds. After launch, position, attitude and velocity reference data are derived from the ALCM's inertial navigation system, mach number and pressure altitude from the air data system, and height above the terrain from the radar altimeter. Initial position/velocity data and atmospheric parameters are transferred to the missile from the B-52G carrier immediately prior to launch. The missile is then guided inertially along preplanned flight profiles at programmed Mach numbers and altitudes. Velocity commands are based on precomputed ground speeds required to reach the target at a specified time.

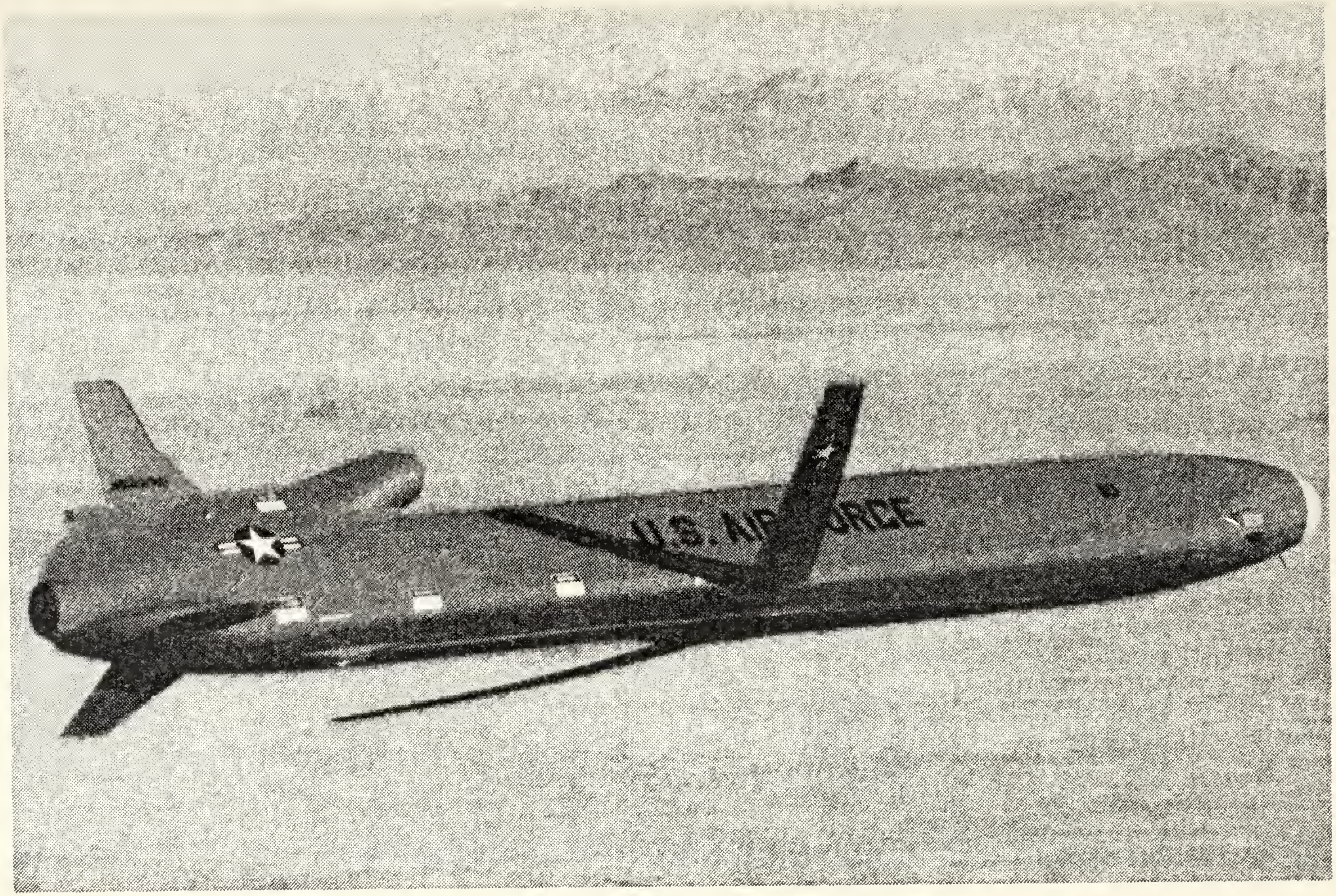


Figure 1. Air Launch Cruise Missile (ALCM)

"Time-to-target" is calculated by the computer, and throttle commands are issued as required to maintain average ground speeds along each trajectory segment. Altitudes are selected to be either "altitude hold", where the missile flies at a commanded barometric altitude, or "terrain following" where the missile flies at a specified height above the terrain.

Guidance is by a combination of an inertial navigation system and a terrain comparison (TERCOM) technique which utilizes the radar altimeter and onboard computer. At predetermined points along its flight path, the missile uses its radar altimeter to map the profile of the terrain below. This "sensed profile" is compared with a preloaded digital map of the surrounding area. (Mapping information will be furnished by the Defense Mapping Agency.) Locating itself within the map, the missile computer determines its true position, velocity, and heading and makes course corrections if necessary. At first landfall, the missile's map may be of an area measuring in the tens of miles. When it updates its position, it also adjusts drift rates, calibrations, and other guidance error contributions to make itself less and less dependent upon map-correlation updates. The radar altimeter then goes into "standby" until it enters the next position update area. Thus, as the missile proceeds toward its target the maps would be of smaller and smaller areas, since the guidance system fine-tunes out practically all

error. TERCOM is said to resolve objects on the ground as small as three meters wide and 30 centimeters tall from an altitude of several thousand meters [Ref. 3]. The TERCOM feature allows the ALCM to fly at low operating altitudes below 100 feet [Ref. 3]. Maximum operating altitude for the radar altimeter is 5000 feet above the ground. All terrain following is performed below this altitude. In the event of radar altimeter failure during terrain following, the missile automatically transfers to the altitude hold mode and flies at a preset barometric altitude stored in the mission software (Figure 11, line #4). This value is selected to provide adequate terrain clearance for the area being overflown.

This high accuracy of missile position updating results in extreme accuracies at the target. U.S. cruise missiles to date have achieved accuracies on the order of 30 feet CEP [Ref. 3]. This means at least 50% of the time the missile will land within 30 feet from the target.

The ALCMs carried by the B-52G are programmed initially with one target per missile. Anytime prior to ALCM launch, a new target can be entered into the missile by the navigator. This retargeting capability is referred to as "flex targeting". Using the current integrated keyboard (IKB), this procedure requires approximately 1-2 minutes per missile to complete. Retargeting a full load of twenty missiles would require 20-40 minutes.

Accelerated production for the USAF/Boeing ALCM at production rates of 480 missiles per year will start in Fiscal 1984. This plan is predicated on the deployment of 3,780 missiles by 1990 on a schedule consistent with B-52G/H conversions [Ref. 4].

3. Role of Navigator

Responsibilities for navigation and weapons control in the B-52G are assigned to the navigator and radar navigator. The navigator determines aircraft position based on radar information obtained by the radar navigator. He compares actual position, course, etc., to preplanned mission course and directs the aircraft accordingly. The navigator is also responsible for ALCM status. If a change in ALCM targets is directed by appropriate authorities, he would be the crewmember to make these changes.

Except during the flex targeting procedure, there are no other inputs the navigator must perform with regard to the ALCM. He does have a constant missile status of each, and if one malfunctions prior to launch, it can be withheld by the navigator and jettisoned if necessary.

4. Scenarios: Tactical & Strategic

The cruise missile carried onboard the B-52G will be capable of performing non-nuclear (tactical) roles as well as its main role in nuclear (strategic) scenarios.

In the tactical scenario rapid retargeting of ALCMs could give defending forces, especially in the European

Theater, an unprecedented capacity for disrupting Soviet Pact supply lines, destroying support facilities, and attacking front-line forces during a massive thrust across Western Europe. A B-52G orbiting outside the battle area could respond to battlefield commanders by launching ALCMs against targets too risky for aircraft strikes, or too far away from artillary positions. Since tactical targets are very mobile, a rapid and accurate ALCM retargeting capability is essential. If a voice entry system significantly improved speed and accuracy then considerable capability would be added to the flex targeting option.

Utilizing a nuclear warhead in a strategic role, cruise missiles can strengthen the air leg of the strategic triad of the U.S. which includes intercontinental ballistic missiles (ICBMs), submarine launched ballistic missiles (SLBMs), and strategic bombers. ALCMs will give heavy bombers a standoff capability, and the missile's long range (1550 miles) would lessen the need for bomber refueling [Ref. 5]. Planners could assign ALCM-equipped B-52Gs a standoff role of firing their missiles outside Russian airspace without actually penetrating, or firing and then penetrating to drop their gravity bombs, or launching ALCMs within Russian airspace as they penetrate. If the flex targeting procedure near or within these high threat areas was exercised, the 1-2 minutes required for retargeting each ALCM would increase the bomber's probability of detection by enemy radar.

C. SPEECH RECOGNITION & CRT DISPLAYS

1. Overview

Ever since machines have been used by man, he has sought ways to have more control over them. With the development of computers, man continued to exercise mechanical control by means of keyboard interfaces or manually punched cards. The ability to directly communicate with them by voice was first envisioned by science fiction writers of the 1950's and 60's. As the computer became faster and able to store larger amounts of information, researchers began investigating the possibility of speech recognition by computer.

The theory behind computer speech recognition (also known as voice data entry) was simple enough, at least for isolated words.

The basic theory is as follows:

1. Air pressure variations, created by speech, are first converted into an electrical signal by microphone.
2. The signal's acoustic features are converted into computer machine language, and stored in computer memory.
3. Because a word does not necessarily have the same length each time a speaker says it, the computer must "time align" its length.
4. The computer then compares the features of the "aligned"

word against utterances already stored in its memory. The computer decides whether the spoken word matches a word in memory.

5. Assuming a match is found, it then performs the action or actions (pre-programmed) corresponding to that utterance.

The computer thus recognizes an utterance, or word, within a given time frame. It also rejects any word whose features are too remote from those stored in its memory.

Speech recognition can be divided into two types. The first is called "isolated speech" or "discrete" recognition. Each utterance is followed by a 0.1-0.2 inter-word pause. In a discrete recognition system, the "utterance" is not limited to just a single word. For example, the Threshold T-600 will allow utterances up to two seconds in length. The second type is called "connected speech" recognition, similiar to normal human speech with no pauses between words. Utterances in connected speech units can thus be made up of many individual words greater than two seconds in duration.

When one goes from computer recognition of individual words (isolated speech), to full sentences as in natural speech (connected speech), the problem is compounded even more. In isolated speech systems, the computer can clearly distinguish between consecutive words. In contrast, natural speech wave forms do not show clearly where one word ends

and the next begins, and the time alignment problem is far more difficult with connected speech than with isolated words. Not only must the computer time-align individual words, it must also repeat this for groups of words or whole sentences. Once an input word is recognized in connected speech systems, the computer must also decide which word is most likely to follow the input word.

2. Value of Speech Recognition Systems

Cochran and Riley [Ref. 7] list the following advantages to computer voice entry:

1. Fast learning time
2. Dual modes of sensory feedback
3. Not restricted to one language
4. Accuracy
5. Simultaneous: Use of hands, use of eyes, data entry
6. Automatic and multiple processing
7. Remote entry
8. Simple data entry

The learning time on a voice input device is shorter than on a keyboard or typewriter, and accuracy is greater during the learning period. Because spoken language is a natural part of life, data entry using voice is easy once the individual and machine are trained. The auditory and visual feedback immediately reinforce correct input and alert the operator to an error [Ref. 7: p. 190].

Because the machine is "trained" to each operator's voice, language and pronunciation are not critical as long as the operator is consistent. This means that regional accents and even foreign languages are acceptable for use with the voice input device [Ref. 7: p. 191].

One of the primary advantages of the voice input device is that it frees the hands and eyes for other tasks while inputing data.

Voice entry can be useful when many different or complex characters need to be entered in succession. The Threshold T-600 can input up to sixteen characters at once with just one utterance.

3. Limitations of Computer Speech Recognition

Although the advantages are numerous and appealing, disadvantages and limitation also exist. These include:

1. Cost - Voice data entry devices vary in cost from $200.00 to over $80,000.00. As advances are made in high-speed integrated circuits, costs will continue to decrease.

2. Voice input can be overheard, making security a problem [Ref. 8].

3. Ambient noise interference.

4. Training and frustration.

5. Limited vocabulary - The user is limited to only the vocabulary which has been loaded into computer memory.

6. Changes in user voice characteristics can require retraining [Ref. 9].

As in all technology, advantages and disadvantages exist. The final test is always the marketplace. In both civilian and military applications, voice units are replacing more and more conventional entry devices. Cartography, air traffic control training, aircraft avionic systems, and military command and control centers are but a few of the present users. Industrial users are improving production line and shipping productivity with these devices by as much as 40% [Ref. 10]. The Navy is utilizing a voice unit at their Fleet Ocean Surveillance Information Center, CINCPAC Fleet, Honolulu, Hawaii, to query their information data base. General Dynamics recently outfitted an F-16 fighter aircraft with a pilot-operated voice unit for feasibility tests.

4. CRT Display Techniques

Two major classes of information display technologies exist today: the cathode-ray tube (CRT) and the plasma panel. The CRT has existed since the 1930's while plasma desplays were developed in the late 1960's. Both use very different techniques to display information.

The CRT utilizes an electron beam to excite a phosphorous coating which in turn emits photons. Images can then be created by directing the electron beam over the phosphorous-coated glass.

A plasma display is similiar in principle to a neon tube. It consists of two parallel glass plates each with many parallel conductors. The plates are separated by a 0.1 millimeter gap filled with neon gas. A voltage between the intersection of two conductors will emit a glow. Many of these points of light can be made to form images.

The B-52G displays were required to display alphanumeric information as well as the radar presentation. This meant a display technique capable of fast updating, which the plasma display is unable to do [Ref. 11]. Thus, the type of display selected for use on the B-52G was the monochromatic CRT. Methods of highlighting information on a monochromatic CRT include:

Flashing - Turning displayed information on and off at approximately 3-5 Hz.

Inverse Video - Alphanumerics displayed as dark characters over a white background.

Location - Position information as in double-spacing.

Highlighting - Achieved by overwriting with the electron gun thus causing the image to stand out.

D. STATEMENT OF THE PROBLEM

Part I of this thesis evaluates operator performance of the flex targeting procedure using the present integrated keyboard (IKB) input device and a voice input device. Operator speed and accuracy were used to evaluate each system. Would voice entry improve the operator's

performance as defined by these parameters? Each subject used both input devices in loading twenty ALCM target sets per device. A "target set" is defined as the data comprised of 45 characters the ALCM needs loaded in its memory to fly to and locate the target (Figure 11).

Part II compares the way in which this information is presently displayed (single-spaced) on the navigator's CRT with two alternative methods of presentation. These two alternatives are double-spacing and inverse-video. Characters displayed in inverse-video are shown as dark figures against a white background. Normally, characters are displayed as white characters over a black background. During the inverse-video portion of Part II, as a line is updated, that line is "inverse-videoed" when reinserted into the target set. It was hoped that this would help the operator in scanning the target set in search for values to be changed out.

A capability of exercising the flex targeting option using voice input might significantly reduce bomber exposure in enemy airspace, while giving military and civilian leaders more time for retargeting decisions based on reconnaissance, changing military and political factors, etc. The method of displaying the flex targeting data on the CRT could also have a similar effect.

E. HYPOTHESIS

The following hypothesis were tested:

1. Hypothesis Regarding TIME

H_0 : There is no difference in Time to enter complete target sets among the two entry modes.

H_1 : Complete target sets will be entered faster using the voice entry mode.

H_0 : There is no difference in Time to verify and correct target sets among the three types of display formats.

H_1 : Target sets will be verified and corrected fastest using the inverse-video format.

2. Hypothesis Regarding ACCURACY

H_0 : There is no difference in the Accuracy of target sets among the two entry modes.

H_1 : Target sets will be entered more accurately using the voice entry mode.

H_0 : There is no difference in Accuracy in verifying and correcting target sets among the three types of display formats.

H_1 : Target sets will be most accurately verified and corrected using the inverse-video format.

II. DESCRIPTION OF THE EXPERIMENT

A. OBJECTIVES AND CONSTRAINTS

The purpose of this experiment was twofold. First, to determine whether computer voice technology was better than keyboard entry for loading the ALCM flex targeting data. The performance of both entry methods, computer voice and the integrated keyboard (IKB), would be measured by subject input speed, accuracy, and time versus accuracy. Second, to determine which of three methods of data presentation on the CRT would be best suited for the flex targeting procedure. The performance of each display presentation would be determined by subject input speed, accuracy, and time versus accuracy in changing displayed flex targeting data.

An effort was made to reconstruct the B-52G navigator's workstation in carrying out these objectives. Only ALCM related controls and displays were incorporated into the mockup (see Figure 2).

B. EQUIPMENT

1. Navigator Position

For the purpose of this thesis we will assume through some communications means the B-52G crew can successfully receive new ALCM targeting information from higher authorities. Also assumed is that the information can be readily decoded and handed to the navigator in paper

form which will then be manually entered into the appropriate ALCM. The keyboard the navigator would use is unique to the B-52G. It interfaces with the Offensive Avionics System (OAS) which controls both navigation and weapons. Both navigator and radar navigator have a keyboard as well as two cathode-ray tube (CRT) displays for each of their postions (see Figures 3,4). In actuality, either operator can change ALCM target information. But in most cases, and for the purpose of this thesis, the navigator will carry out the procedure (see Table I).

In simulating the operation of this crew position at the Human Factors Laboratory, an APPLE II "plus" 64K minicomputer and a CONRAC 7 x 5 inch CRT display were positioned in front of and above the subject's seat position. A keyboard was built to look and operate like the integrated keyboard (IKB) found currently in the B-52G.

The navigator's position dimensions and equipment location for this experiment were obtained from the OAS-configured T-10 navigation simulator located at Wright-Patterson Air Force Base.

2. Integrated Keyboard (IKB)

In order to measure target set entry times by keyboard, a working model of the IKB used in the B-52G was built. Its dimensions and pertinent keys were duplicated exactly (see Figure 5,6). The IKB was connected via a Lear Siegler Inc. ADM-3A terminal to an APPLE II minicomputer.

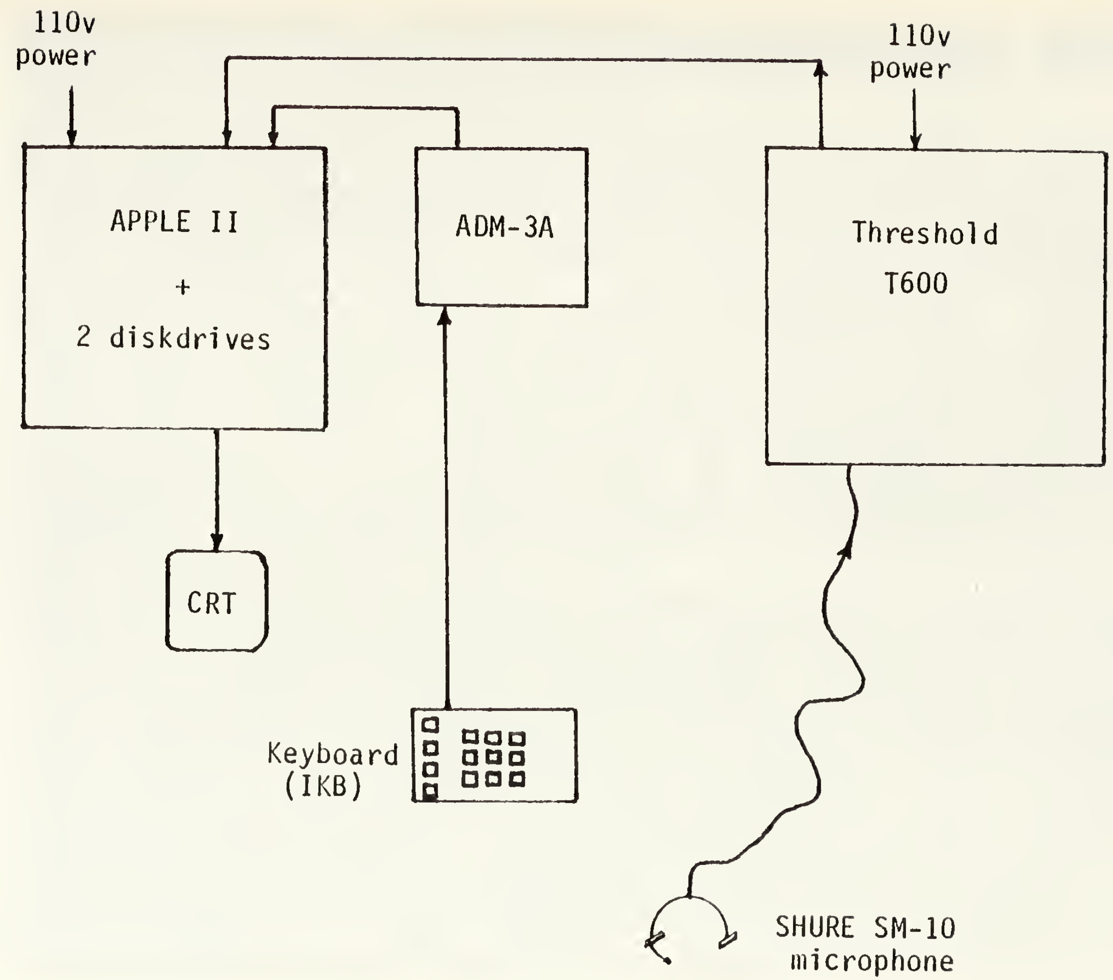


Figure 2. Diagram of Equipment Setup

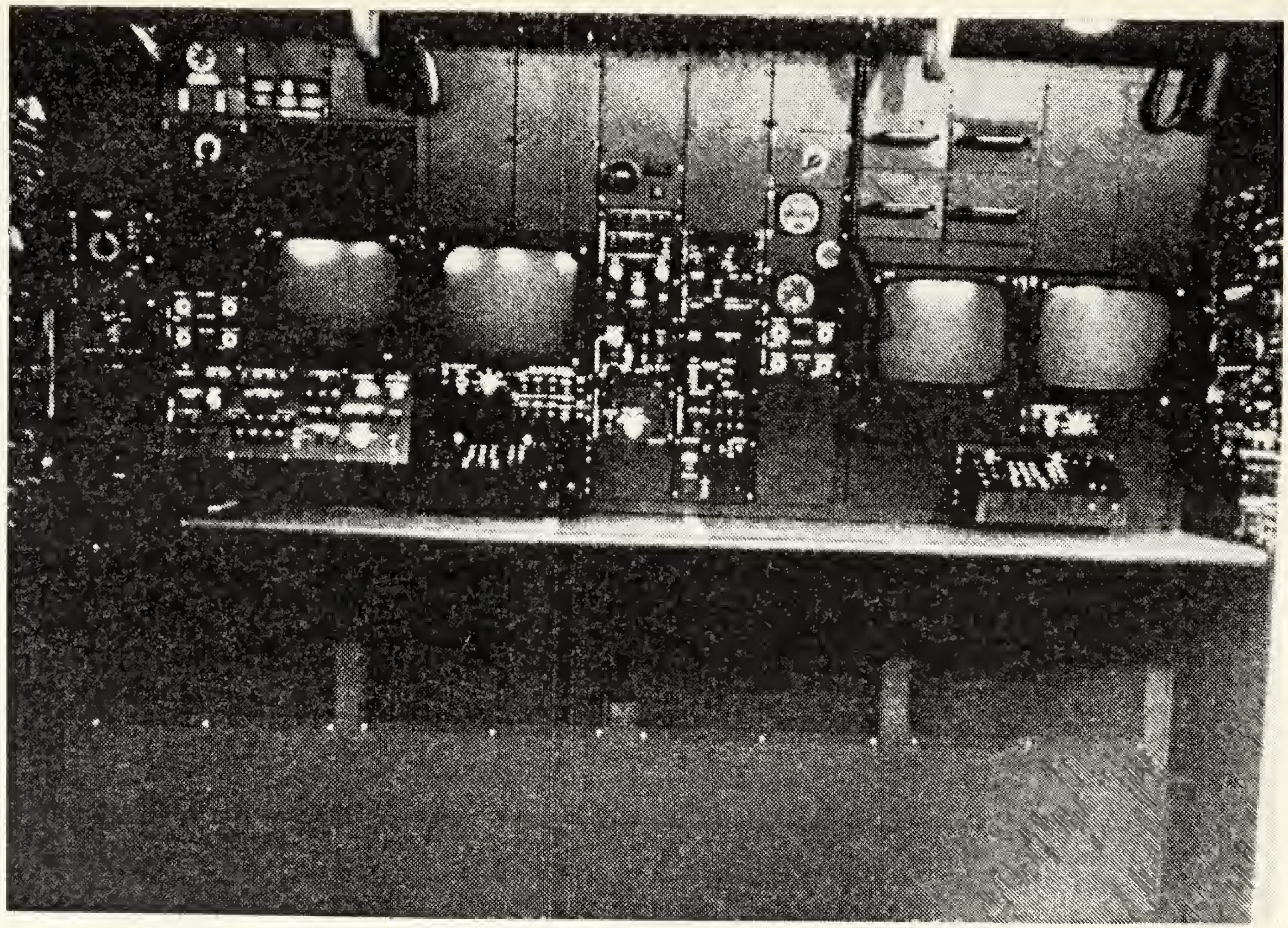


Figure 3. Radar Navigator/Navigator Positions, B-52G

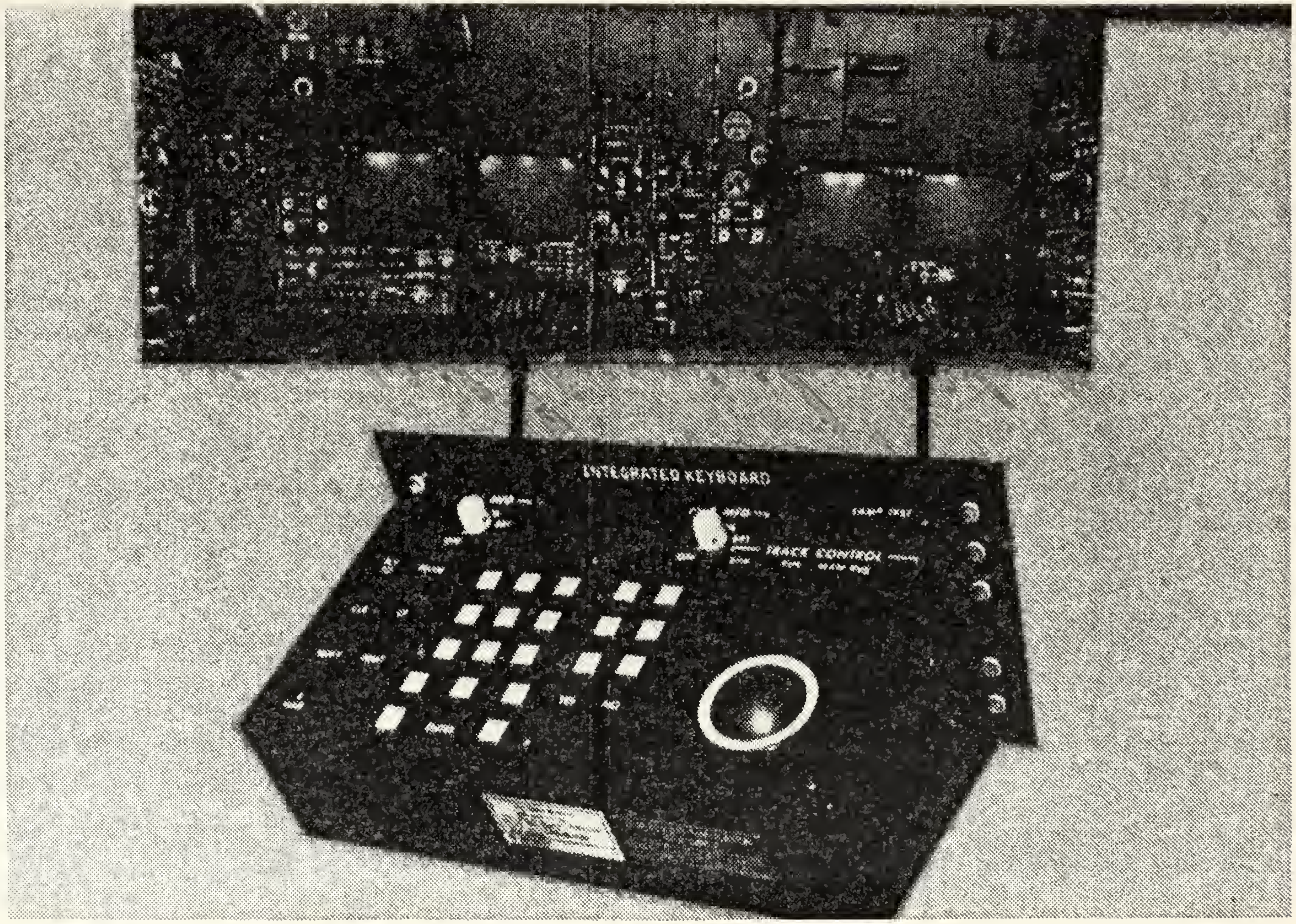


Figure 4. IKB at Radar Navigator/Navigator Positions

The ADM-3A was needed because the APPLE II design did not allow direct connection of the IKB to the APPLE II's keyboard plug directly.

3. Apple II Computer

An APPLE II "plus" 64K RAM (Random Access Memory) minicomputer was used to control all video displays on the CONRAC CRT (see Figure 7). As each subject entered target set data, the information was stored in main memory to be printed out after the session using a MICROLINE Micron 80 printer. These printouts were later used to check for input errors.

4. Voice Recognition System: T600

A Threshold Technology Inc. T-600 (hereafter referred to as the T600) was used as the voice recognition input device (see Figure 8). It is a commercially available device capable of recognizing up to 256 spoken words or phrases. These phrases or utterances as they are called must be limited to 0.1-2.0 seconds in length [Ref. 12].

A short pause of at least 0.1 second is required between each utterance. Thus the T600 is referred to as an isolated or discrete speech voice recognition unit. The T600 voice recognition system consists of a main terminal processor unit containing a speech preprocessor and microcomputer. The remaining components, the tape cartridge unit, the microphone preamplifier and display (present but not used during experiment) are connected separately.

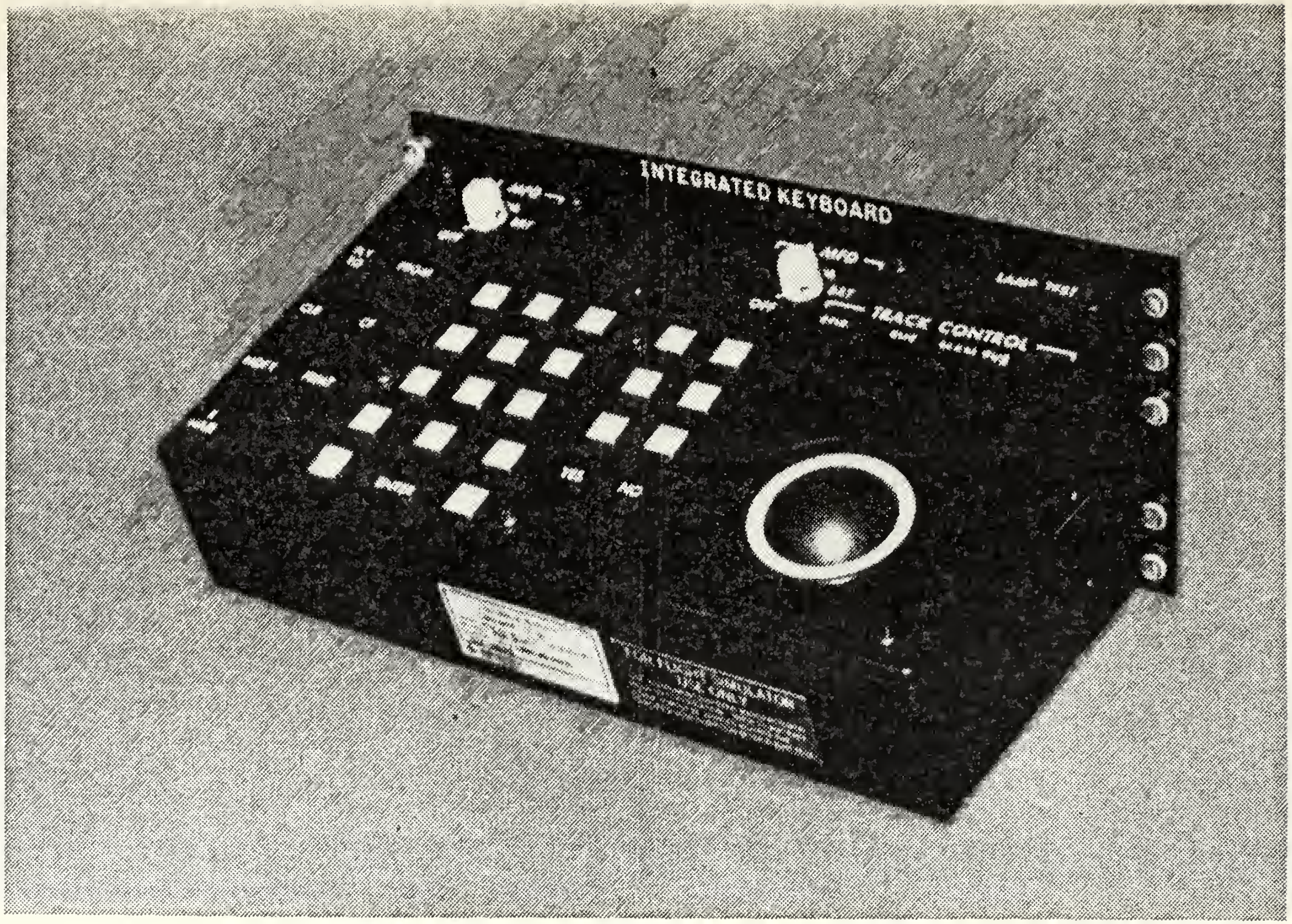


Figure 5. Actual Integrated Keyboard (IKB)

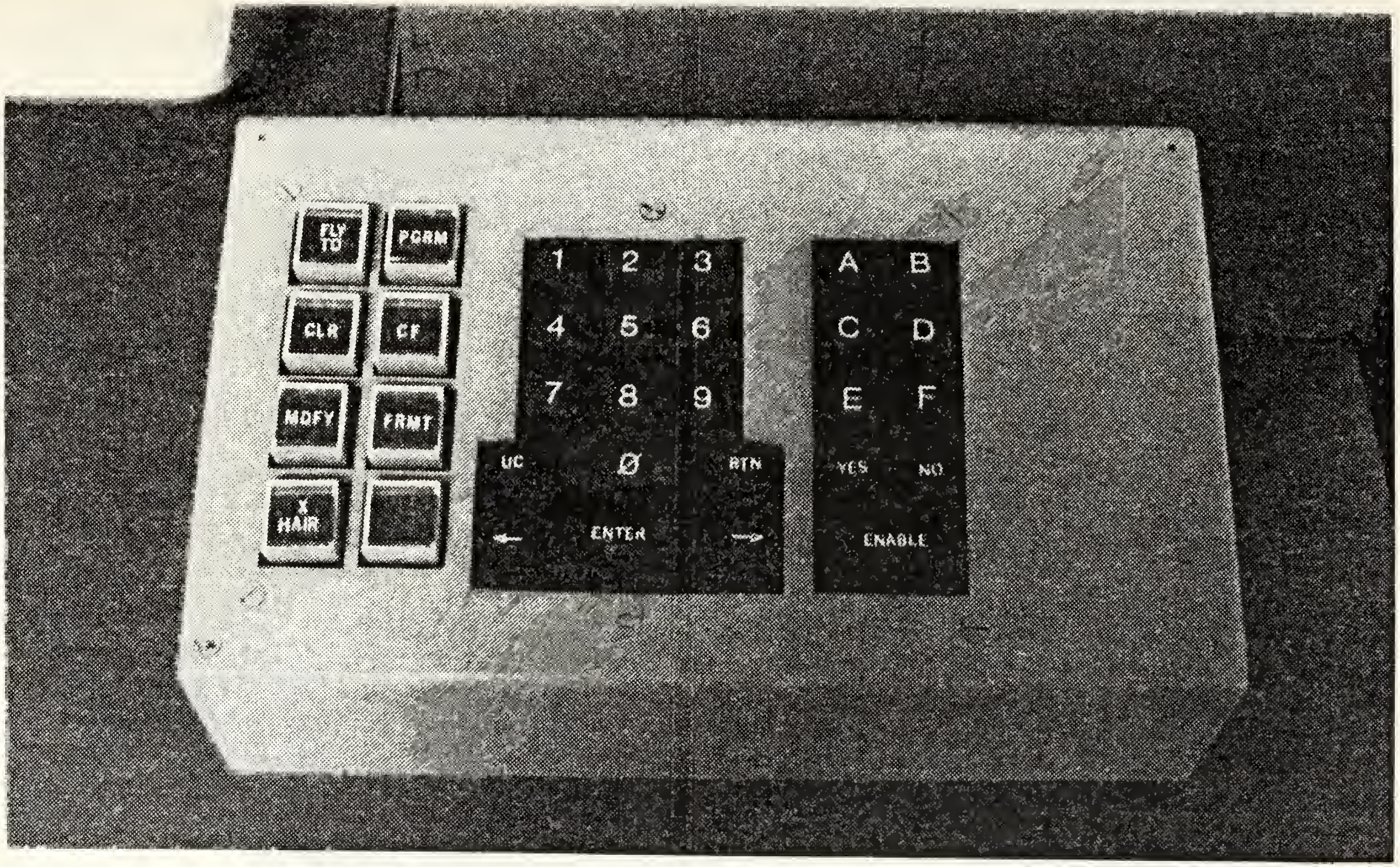


Figure 6. Working Model of Integrated Keyboard (IKB)

Figure 7. APPLE II Computer and CONRAC CRT

The microphone used was a noise cancelling SHURE SM-10. The T600 was connected to the APPLE II via an APPLE serial interface with RS-232 standard input/output.

When the T600 receives an utterance spoken by a subject, the voice unit will react in one of two ways. The utterance will be compared with those patterns in memory, and, if a match is found, the corresponding output string will be transmitted. The alternative is that no match will be found between the utterance received by the T600 and that programmed in its memory. If the latter occurs, an audible "beep" is sounded with no output string transmitted. This is referred to as a nonrecognition. It can result from either mispronunciation of the utterance, poor initial training of the word, background noise being interpreted by the T600 as an utterance, or lack of T600 reliability.

C. SUBJECT SELECTION AND TRAINING

1. Subject Selection

Subjects used for this experiment were students and faculty of the Naval Postgraduate School. Four were female and sixteen male. All except five had no previous experience with voice entry and none had used a B-52G IKB prior to this experiment. Seventeen were active duty U.S. military officers and three were civilians.

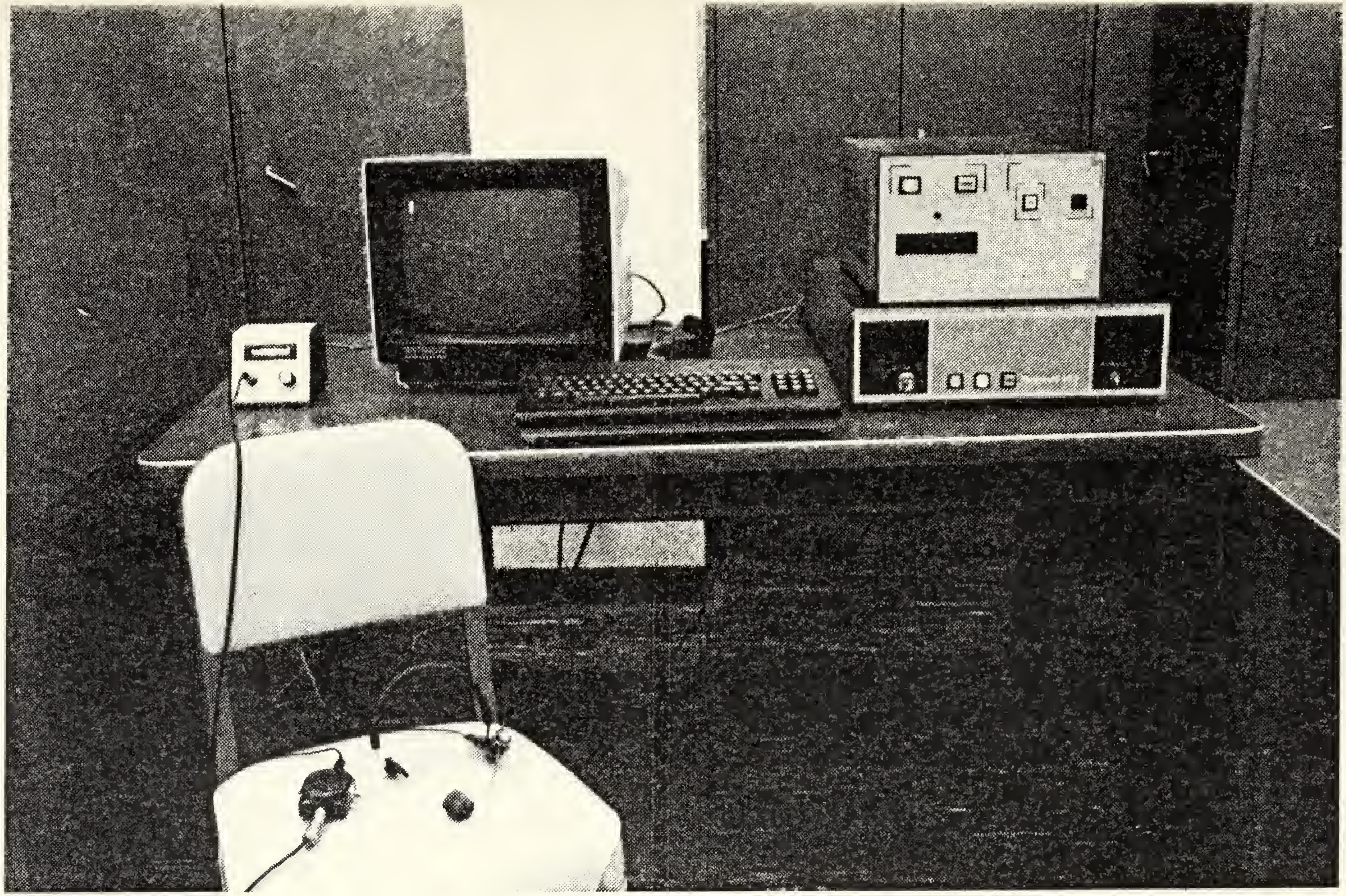


Figure 8. T600 Voice Recognition Equipment

2. T600 Vocabulary Training

Before the T600 could be used as an input device in place of the IKB, voice patterns for all input commands had to be recorded into the T600's memory. This is referred to as "training". Subjects would repeat each of the twenty vocabulary words (see Appendix A) ten times into the microphone. The microcomputer within the T600 averages the ten utterances into one digital pattern of that word. This training was done for each of the twenty words. Each vocabulary word had a corresponding output string. Thus, if the T600 recognizes an utterance as "zero", it would output a "0", and so on. The output string in the T600 can be up to sixteen characters in length.

After the twenty words were trained, each was repeated three times to confirm the T600 was able to identify them. If a misrecognition or a nonrecognition ("beep" sound) occurred 2 out of 3 times or greater for a given word, it was retrained.

3. Integrated Keyboard Training

All subjects had never seen an IKB before participating in this experiment. As stated in the "Script And Instructions To Subjects" (see Appendix B), the operation of the IKB was shown to each subject and each was allowed unlimited practice using a sample computer program until they felt comfortable with the IKB.

D. DEPENDENT VARIABLES

The following variables were calculated for each group of 20 target sets:

$$\% \text{ Input Accuracy Typing (IAT)} = \frac{NCE}{NCE + NICE + NME} \times 100$$

$$\% \text{ Output Accuracy Typing (OAT)} = \frac{NCC}{NCC + NIC + NMC} \times 100$$

$$\% \text{ Input Accuracy Voice (IAV)} = \frac{NCE}{NCE + NICE + NME} \times 100$$

$$\% \text{ Output Accuracy Voice (OAV)} = \frac{NCC}{NCC + NIC + NMC} \times 100$$

Legend:
- NCC : Number of Correct Characters = 45/target set
- NMC : Number of Missing Characters (same as NME)
- NIC : Number of Incorrect Characters
- NCE : Number of Correct Entries = 68 max/target set
- NME : Number of Missing Entries (same as NMC)
- NICE : Number of Incorrect Entries

Character - Displayed entries which are ultimately loaded into the ALCM.

Entry - An input which may or may not be ultimately loaded into the ALCM.

$$\% \text{ Correct Entries} = \frac{NCE}{NME + TNE} \times 100$$

Legend: NCE : Number of Correct Entries = 68 max/target set
NME : Number of Missing Entries (same as NMC)
TNE : Total Number of Entries =
NCE + NICE + NFUTCE

Character - Displayed entries which are ultimately loaded into the ALCM.

Entry - An input which may or may not be ultimately loaded into the ALCM.

E. EXPERIMENTAL DESIGN AND PROCEDURE

Each subject first performed Part I, the "Target Loading Task", in which he first entered 20 ALCM target sets beginning with either the Integrated Keyboard (IKB) or the T600 voice input device (see Appendix C for subject order). Part I of this thesis was a two-way design as illustrated in Figure 9. Subject order with the two conditions was determined using an ABBA ordering method. This was repeated using the second entry method with the same target sets. Performance of each subject was recorded using data sheets shown in Appendix D. The twenty target sets used in Part I are contained in Appendix E.

Part II was a two-way design as illustrated in Figure 10. This part of the thesis was called the "Target Information Verification Task". Here the subject was required to examine each of eighteen target sets, ordered in three groups of six , which had been preloaded by the author (see Appendix F).

		VOICE	IKB
	1		
	2		
	3		
S	4		
	5		
U	6		
	7		
B	8		
	9		
J	10		
	11		
E	12		
	13		
C	14		
	15		
T	16		
	17		
S	18		
	19		
	20		

TARGET LOADING
TASK

CONCEPTUAL DESIGN (PART I)

Figure 9

He then compared each to a list in which various characters had been changed. Changes varied from 0 to 9 characters per set. Some target sets required no corrections, while others required many (see Appendix G). The subject had to locate each value in the target set to be changed, and make the required changes (see Figure 11). Only the Integrated Keyboard (IKB) was used as the entry device for Part II.

		SINGLE-SPACE	DOUBLE-SPACE	INVERSE-VIDEO
	1			
	2			
	3			
S	4			
	5			
U	6			
	7			
B	8			
	9			
J	10			
	11			
E	12			
	13			
C	14			
	15			
T	16			
	17			
S	18			
	19			
	20			

TARGET INFORMATION VERIFICATION TASK

CONCEPTUAL DESIGN (PART II)

Figure 10

Each of the three groups of six target sets required a total of 26 randomly distributed changes per group. group. The first set of six target sets was displayed in a single-spaced format as is presently done in the B-52G (Fig. 11). The second set of six was displayed in double-spaced form. The third set of six was displayed single-spaced, but as a line was modified, that line then became displayed in inverse-video form. Characters displayed in inverse-video are shown as dark figures against a white background. For details of the experimental procedure, see Appendix B.

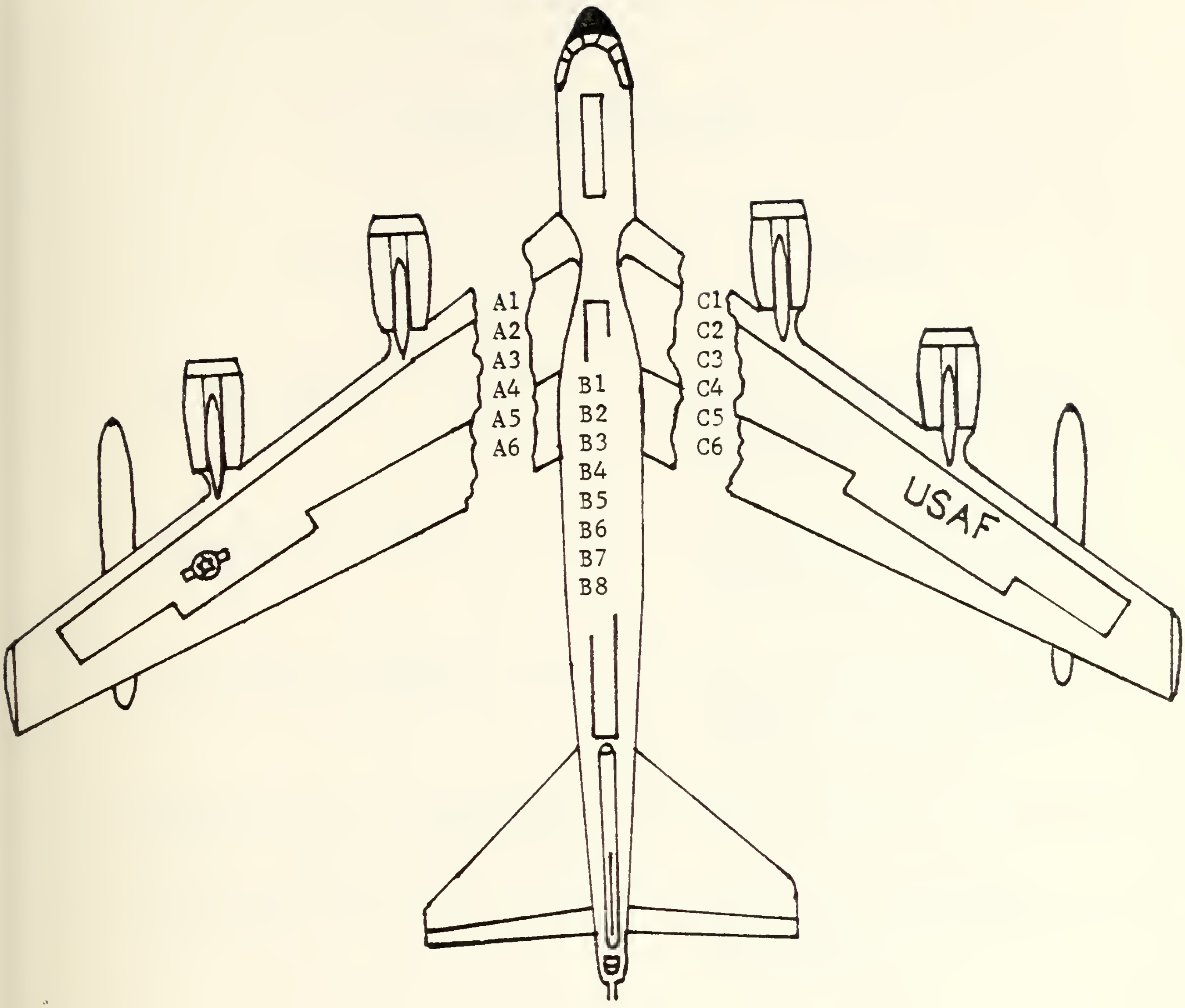
```
FLEX TARGETING


1 NØØØØØØØØ     <------------ target latitude
2 EØØØØØØØØØ    <------------ target longitude
3 ØØØØØØØØØØ    <------------\
4 ØØØØØØØØØØØ   <-------------\
5 ØØØØØ         <--------------\flightpath information
                                    required by ALCM


MODIFY NØØØØØØØØØ             <---------- line #1 ready
                                          to be modified
          \----- cursor
```

TARGET SET FORMAT CURRENTLY USED FOR FLEX TARGETING
(Adapted from Reference 6)

FIGURE 11



ALCM LOCATION AND IDENTIFICATION CODES

Figure 12

TABLE I

RETARGETING PROCEDURE

ACTION	RESPONSE
1. Desired ALCM is selected by navigator.	1. CRT in front of navigator displays target information as shown in Figure 11.
2. Line #1 is selected to be changed.	2. Line #1 is repeated at bottom of CRT ready to be changed as shown in Figure 11.
3. New data is entered using keyboard for line #1.	3. New line #1 appears at bottom of CRT as it is typed, overwriting the original line #1.
4. New line #1 is completed; "ENTER" button is pressed.	4. Old line #1 is replaced by new line #1.
5. Line #2 is selected to be changed.	5. Line #2 is repeated at bottom of CRT ready to be changed.

This procedure is continued until all five lines have been changed out. After the last line (#5) has been entered, the ALCM is ready for launch against its new target.

In Parts I and II, subjects called up each target set as is done in the B-52G using a letter-number combination. The six ALCMs stored under the left aircraft pylon are referred to as A1 through A6. The eight stored in the bomb bay are referred to as B1 through B8. The six ALCMs stored under the right aircraft pylon are referred to as C1 through C6. Figure 12 shows pictorally the identification and position of each ALCM.

III. RESULTS

A. INTRODUCTION

Results for Part I (Target Loading Task) and Part II (Target Information Verification Task) will be discussed separately. For each, the results are subdivided into Time, Input and Output Accuracies, and Time versus Accuracy. Raw data analyzed in this section is contained in Appendixes H and I.

B. RESULTS FOR PART I

1. Time

Figure 13 is a plot showing the time required for each subject to load all twenty target sets. Keyboard entry was faster than the voice entry technique for fifteen of the nineteen subjects. No difference was noted in the time to complete using either technique for one subject, while voice entry was faster for three subjects. The five subjects at the far right of the graph had previous experience with voice entry. Analysis of Figure 13 indicates no marked difference among those with prior voice entry experience. Mean and standard deviation for the voice data are 27.56 and 3.42 respectively. Mean and standard deviation for the IKB data are 24.64 and 5.15 respectively.

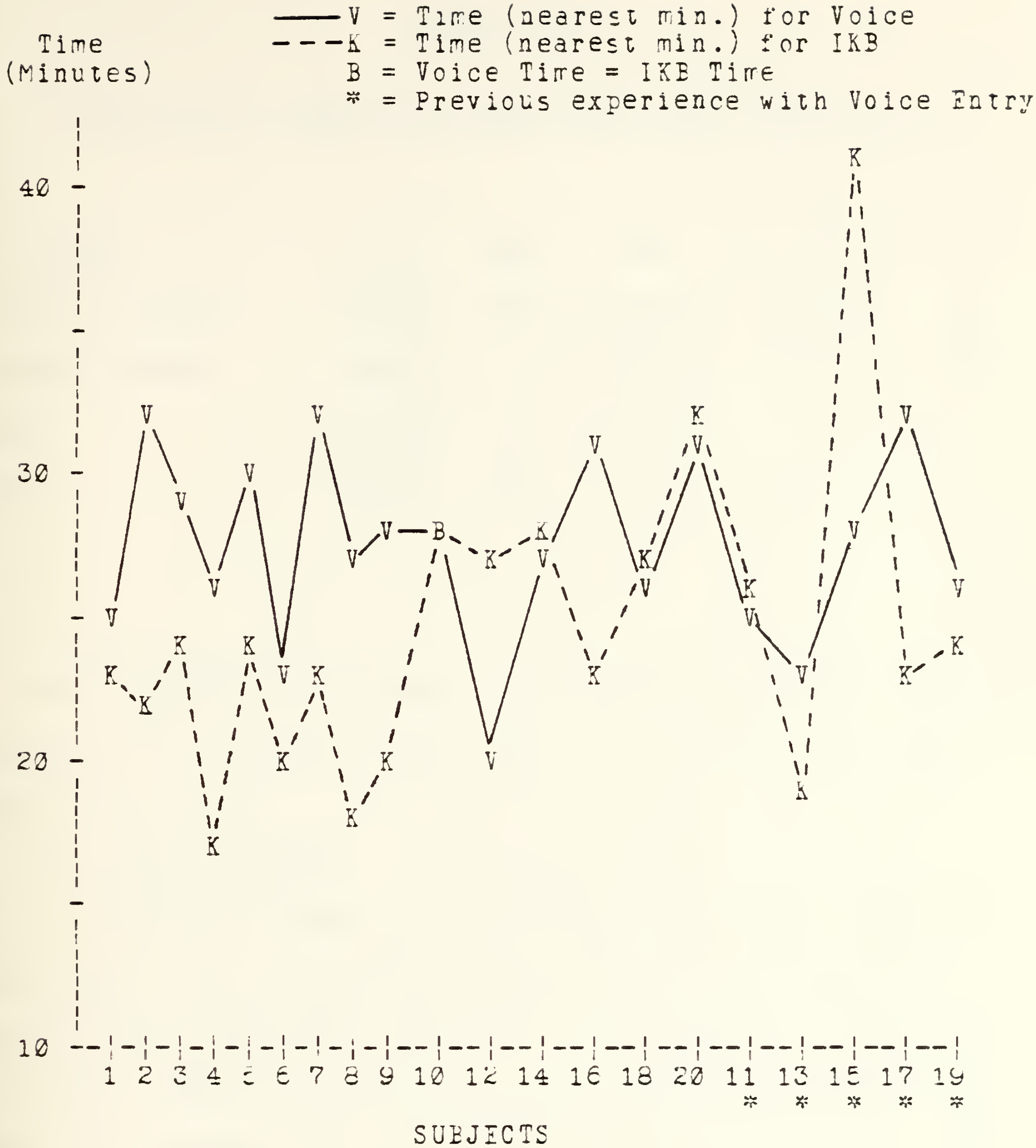


Figure 13. Time by Subject

TABLE II

ANALYSIS OF VARIANCE: SUBJECT BY TIME - PART I

SOURCE	SS	df	MS	F	P
Between Subjects	412.43	19	21.71	1.32	ns
Between Methods	85.24	1	85.24	5.18	<.05
Error	312.84	19	16.47		
Total	810.52	39			

The Integrated Keyboard input method proved to be significantly quicker than the voice method as shown in Table II ($P < .05$).

2. <u>Input Accuracy</u>

Figure 14 shows Subject by Percent Input Accuracy. The IKB percent input accuracy was higher for 74 percent of the subjects. Voice was better for 26 percent. This was confirmed using an Analysis of Variance shown in Table III. IKB input accuracy was significantly better ($P < .01$) than voice entry. (In order to meet requirements regarding the distributions of the data, an arc-sine transformation was applied to the percent input accuracies prior to performing the Analysis of Variance.)

TABLE III

ANALYSIS OF VARIANCE: SUBJECT BY INPUT ACCURACY - PART I

SOURCE	SS	df	MS	F	P
Between Subjects	0.5759	19	0.0303	1.31	
Between Methods	0.2538	1	0.2538	10.99	<.01
Error	0.4383	19	0.0231		
Total	1.2680	39			

3. Output Accuracy

Figure 15 shows Subject versus Percent Output Accuracy. Analysis of Variance in Table IV confirmed no significant difference between voice and IKB percent output accuracies existed. (In order to meet requirements regarding the distributions of the data, an arc-sine transformation was applied to the percent output accuracies prior to performing the Analysis of Variance.)

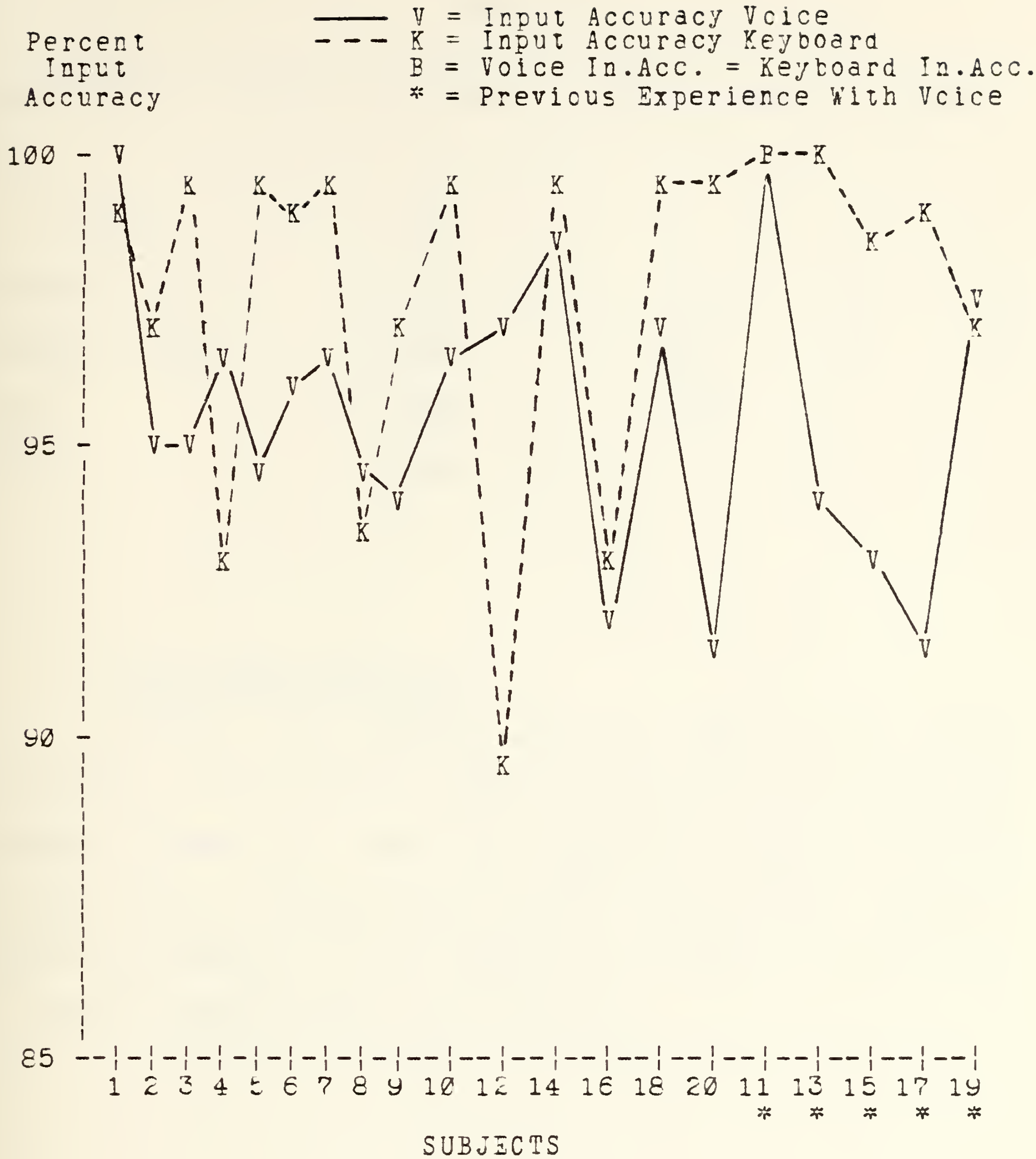


Figure 14. Input Accuracy by Subject

TABLE IV

ANALYSIS OF VARIANCE: SUBJECT BY OUTPUT ACCURACY - PART I

SOURCE	SS	df	MS	F	P
Between Subjects	0.7946	19	0.0418	<1	ns
Between Methods	0.0214	1	0.0214	<1	ns
Error	1.0595	19	0.0558		
Total	1.8755	39			

4. Time Versus Accuracy

Figures 16 through 19 show Input and Output Accuracies plotted against Time for both voice and IKB entry methods. Figure 16 shows no apparent tradeoff between Percent Input Accuracy and Time for voice entry. However, Figure 17 through 19 show pronounced increases in accuracies as time to complete the task increased.

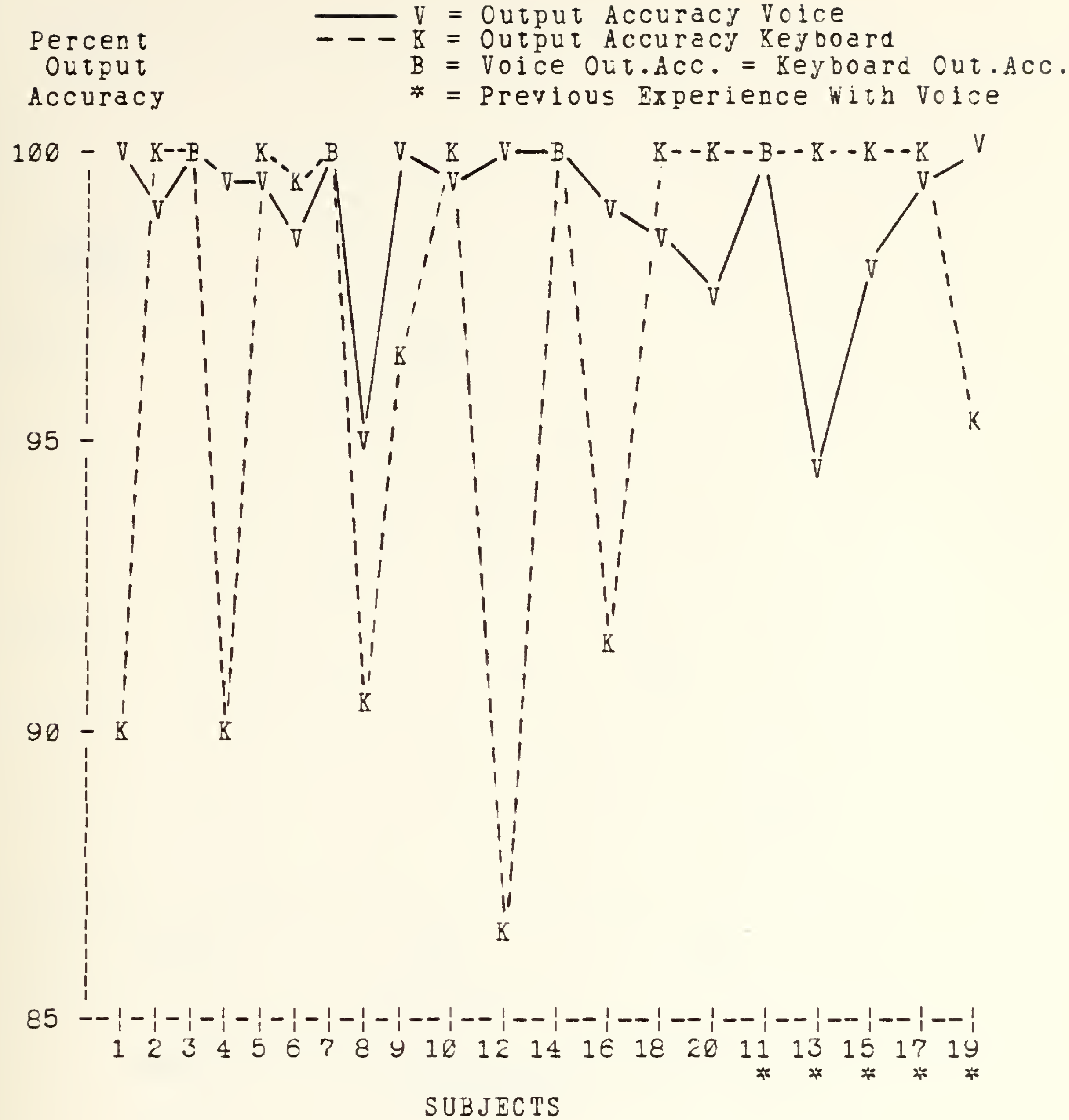


Figure 15. Output Accuracy by Subject

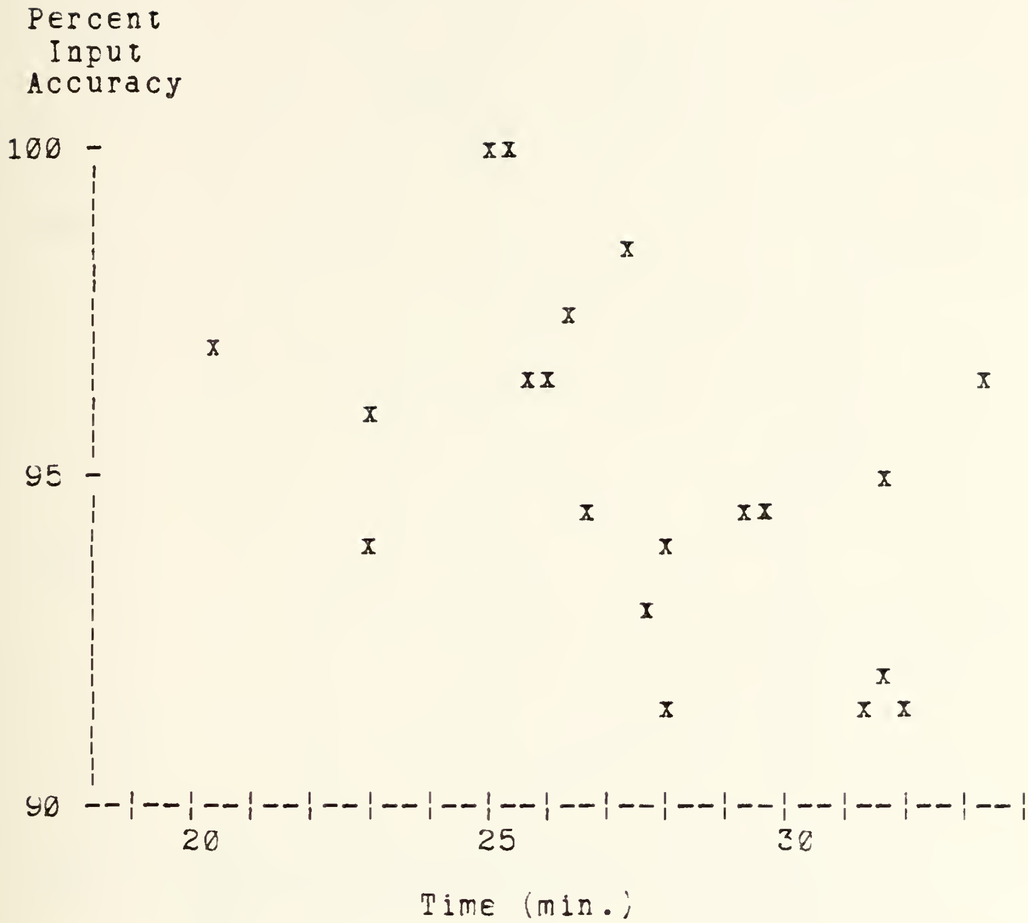


Figure 16. Percent Input Accuracy by Time
For Voice

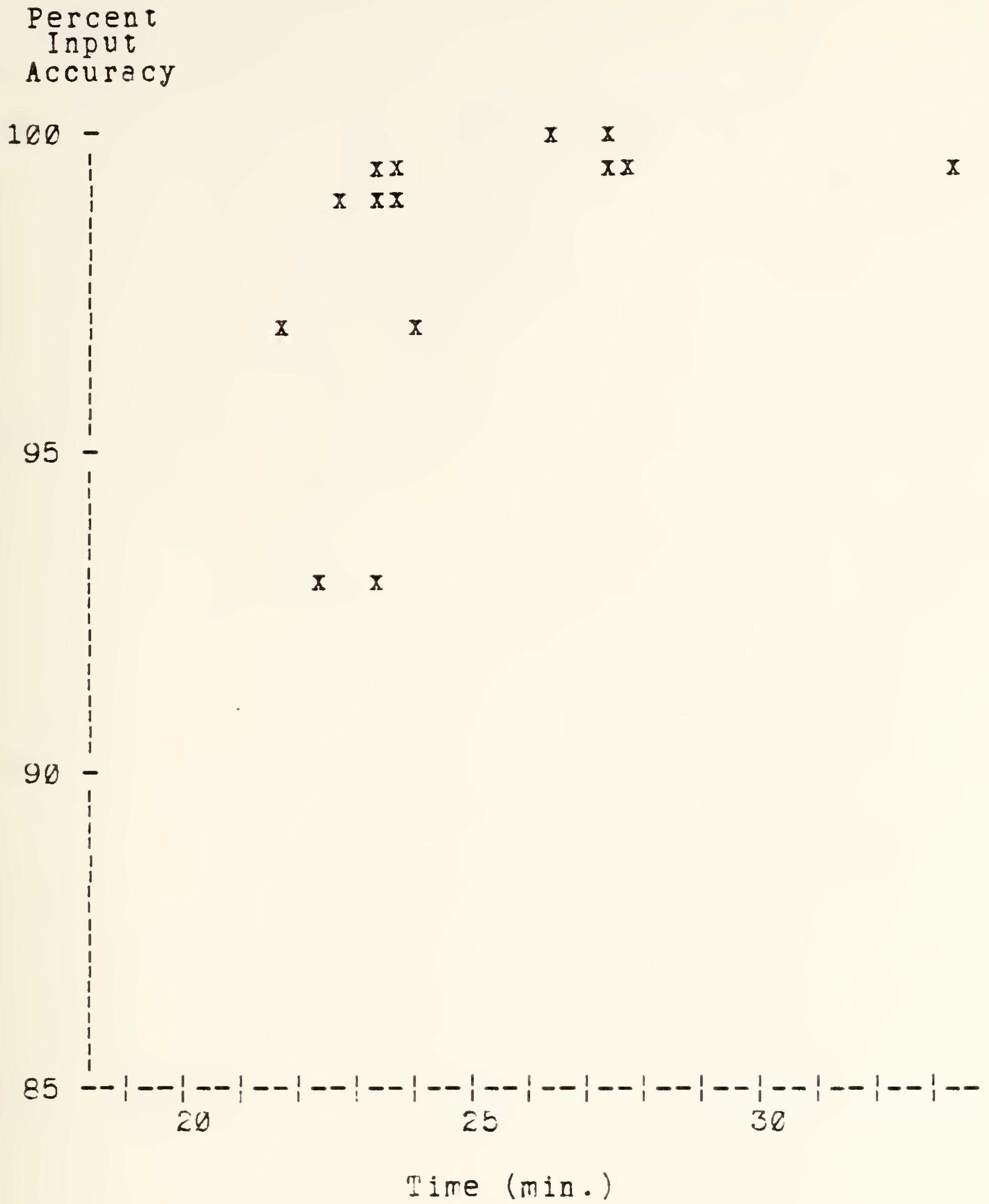


Figure 17. Percent Input Accuracy by Time
For IKB

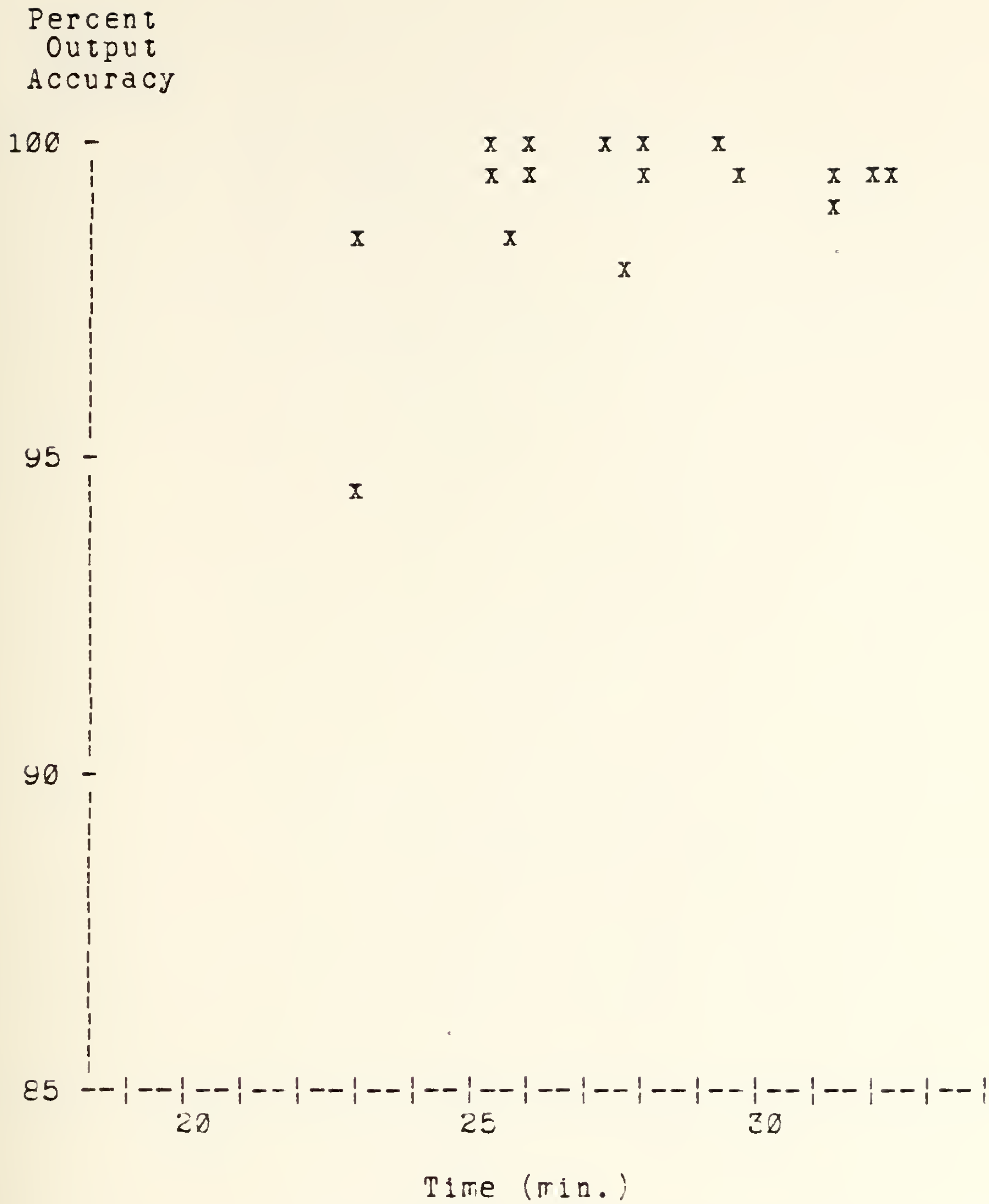


Figure 18. Percent Output Accuracy by Time
For Voice

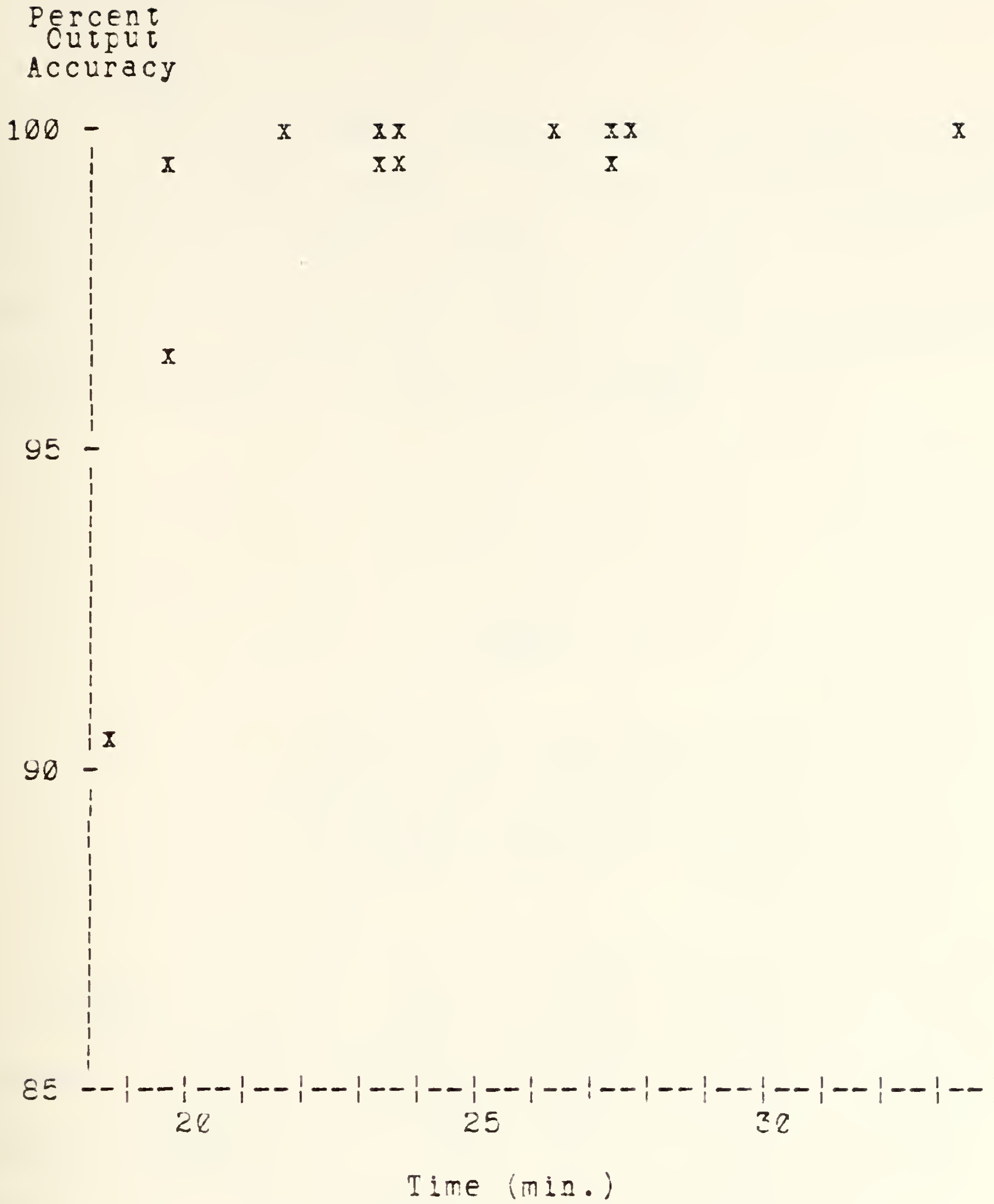


Figure 19. Percent Output Accuracy by Time For IKB

C. RESULTS FOR PART II

1. Time

Figure 20 shows average times for each of the three display formats tested. Analysis of Variance between the three display formats shown in Table V indicated no significant differences. However, a significant difference between subjects ($P < .01$) was detected.

TABLE V

ANALYSIS OF VARIANCE: TIME BY DISPLAY FORMATS - PART II

SOURCE	SS	df	MS	F	P
Between Subjects	37.52	19	1.97	4.48	<.01
Between Methods	1.15	2	0.57	1.30	ns
Error	16.78	38	0.44		
Total	55.45	59			

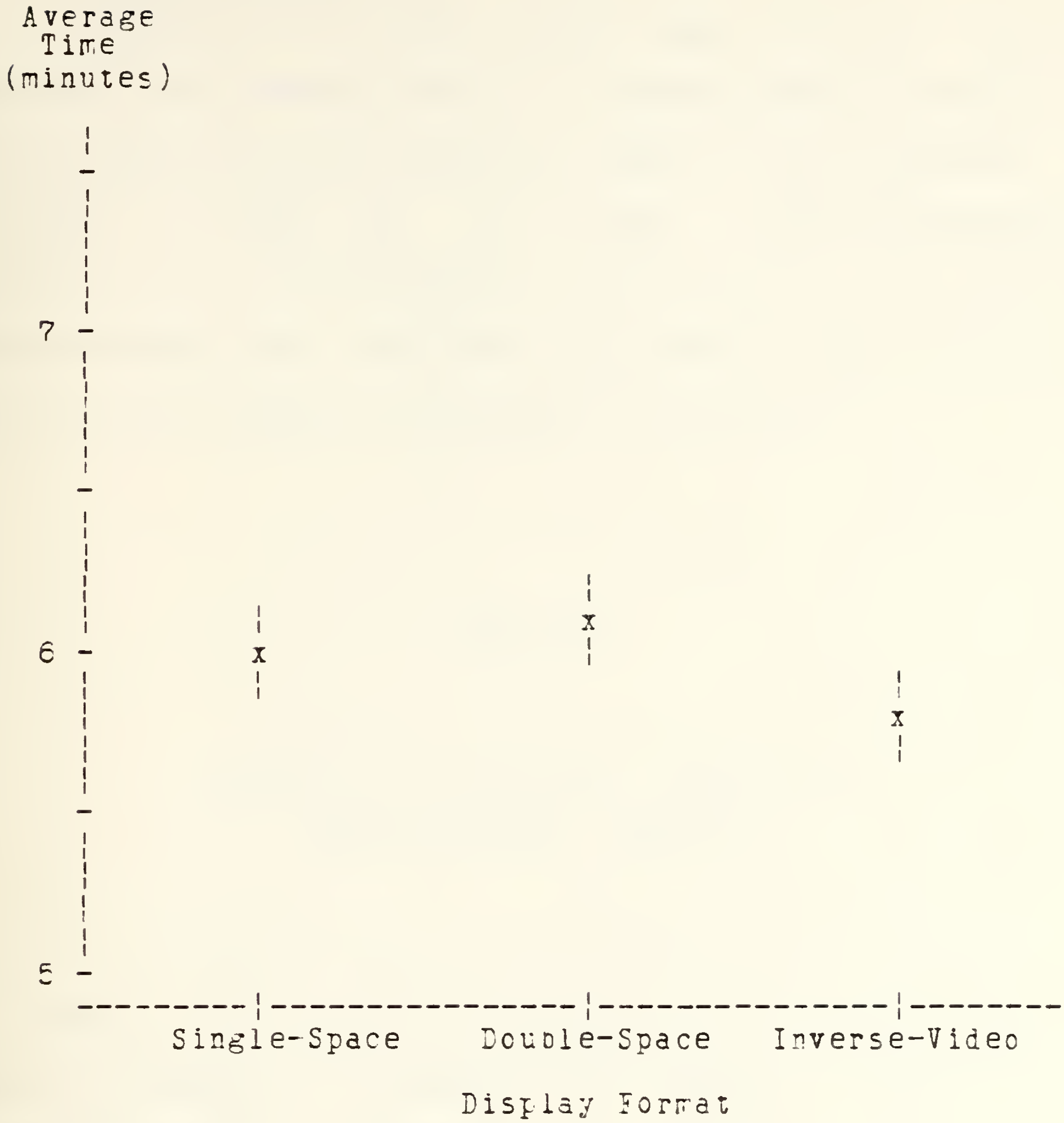


Figure 20. Mean Time And Standard Deviation to Complete Update Using Each Display Format

2. Input Accuracy

Figure 21 shows Mean Input Accuracy plotted against each Display Format. No significant difference was found between display formats as shown in the Analysis of Variance in Table VI. (In order to meet requirements regarding the distributions of the data, an arc-sine transformation was applied to the percent input accuracies prior to performing the Analysis of Variance.)

TABLE VI

ANALYSIS OF VARIANCE: SUBJECT BY INPUT ACCURACY - PART II

SOURCE	SS	df	MS	F	P
Between Subjects	0.9408	19	0.0495	1.10	ns
Between Methods	0.0233	2	0.0116	<1	ns
Error	1.7105	38	0.0450		
Total	2.6746	59			

Figure 21. Mean Input Accuracy And Standard Deviation For Each Display Format

3. Output Accuracy

Figure 22 shows Mean Output Accuracy plotted against each Display Format. No significant differences were computed as shown in the Analysis of Variance in Table VII. (In order to meet requirements regarding the distributions of the data, an arc-sine transformation was applied to the percent output accuracies prior to performing the Analysis of Variance.)

TABLE VII

ANALYSIS OF VARIANCE: SUBJECT BY OUTPUT ACCURACY - PART II

SOURCE	SS	df	MS	F	P
Between Subjects	2.610	19	0.138	1.64	ns
Between Methods	0.096	2	0.048	<1	ns
Error	3.189	38	0.084		
Total	5.895	59			

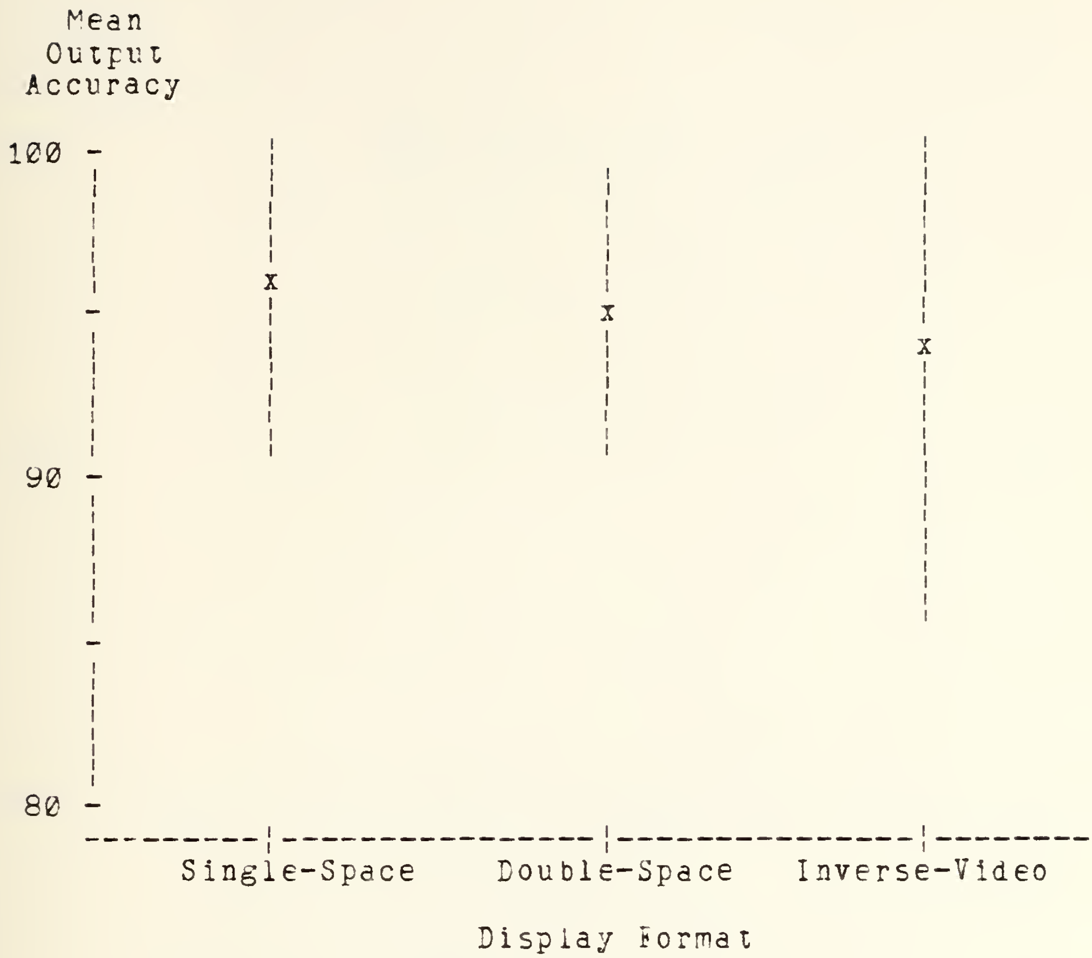


Figure 22. Mean Output Accuracy And Standard Deviation For Each Display Format

4. <u>Time Versus Accuracy</u>

Analysis of Variance for subject times and input and output accuracies showed no significant differences. However, plots of Percent Input Accuracy versus Time for the three display formats indicate the double-space format resulted in the best percent input accuracy over time.

Figure 23. Percent Input Accuracy by Time (Single-Space)

Figures 23 and 25 show data scattered over wider ranges as compared with Figure 24 which shows good clustering above the 95 percent level.

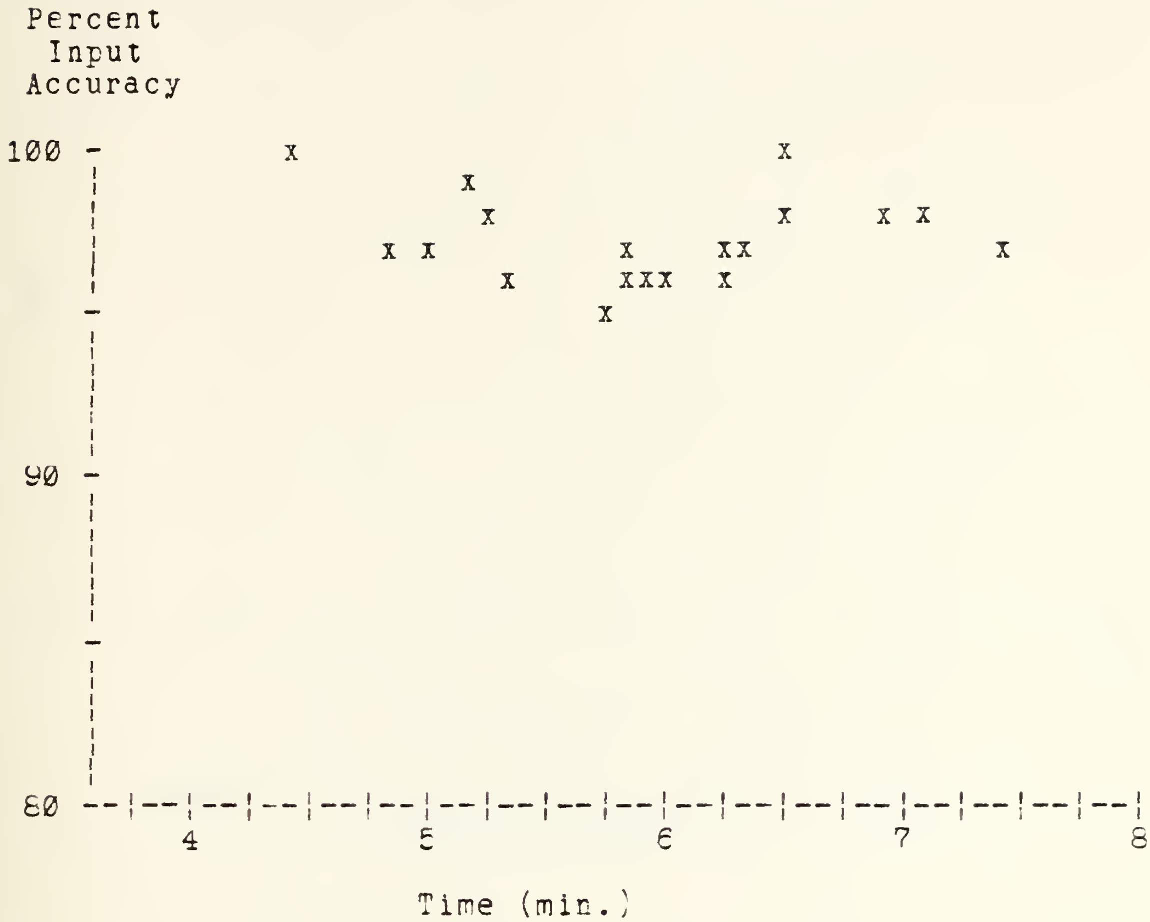


Figure 24. Percent Input Accuracy by Time
(Double-Space)

Figure 25. Percent Input Accuracy by Time (Inverse-Video)

An examination of the Percent Output Accuracy by Time plots showed no significant grouping of the data in all three display formats.

IV. CONCLUSIONS AND RECOMMENDATIONS

A. GENERAL

The purpose of this thesis has been twofold. Part I investigated the use of a discrete voice entry system in loading Air Launch Cruise Missile (ALCM) target information. A direct comparison was made between voice entry and the integrated keyboard (IKB) presently operational. Time to load, input and output accuracies, and time versus accuracy measurements were recorded for each of the twenty subjects.

Part II investigated three means of displaying the ALCM target information on a CRT. Information was updated using single-spaced, double-spaced, and inverse-video formats. Only the IKB was used in Part II. Time to update, input an output accuracies and time versus accuracy measurements were recorded for each subject.

B. CONCLUSIONS

1. Part I

It had been hypothesized that target sets would be entered faster using the voice entry method. However, the IKB was significantly faster ($P < .05$) than the voice method. It was suspected that this may have been due in part to first time use of the voice entry device by fifteen out of twenty subjects. Due to experimental time constraints, subjects had at most 15-30 minutes to practice

with voice entry prior to running the experiment. However, analysis of Figure 13 shows that only two out of the five subjects with prior voice entry experience accomplished data entry quicker using voice. Thus, prior exposure to voice did not improve subject entry times. It should be noted that despite slower input speeds using voice entry, 60 percent of the subjects preferred voice entry use over the IKB.

It should be noted that a discrete voice unit was used for this experiment. However, a "connected speech" recognition unit would have been more appropriate for this task, and probably would have shown faster input times. A connected speech system is able to receive multiple inputs at once, ie., "1-4-3-2-5", with no pause between utterances. This more natural speech would be more comparable with keyboard entry than the discrete voice entry. Unfortunately such a system was not available.

It was hypothesized that target sets would be entered more accurately using the voice entry method. The IKB was significantly higher in input accuracy ($P < .01$) than voice entry. Thus fewer corrections were made to data on the screen before committing it to the weapon using the IKB entry technique rather than voice entry.

Another factor which effected input accuracy was the training of the voice unit by the subject. Each utterance was repeated three times in order to detect poor training.

If the voice unit had problems recognizing an utterance either after training or during practice, that word was retrained. In many instances it was not noticed until well into the experiment that certain words had either been poorly trained or were being pronounced differently by the subject. Changes in pronunciation may also be attributed to the stress imposed by the experiment which was not present during the vocabulary training session. Regardless of the explaination, subjects made less errors using the IKB method of entry.

No significant difference in the output accuracy existed between input devices. This indicates the data was checked equally well by each subject prior to entering the data and moving on to the next weapon, irrespective of entry technique.

No apparent tradeoff was noted between Percent Input Accuracy and Time for voice entry (see Figure 16). However, pronounced increases in accuracy were noted for Percent Input Accuracy by Time using the IKB (see Figures 17).

Possible fatigue was suspected during the voice entry portion in Part I. Subsequent analysis of all misrecognitions and nonrecognitions over the twenty target sets showed an increase in average errors as the the experiment progressed, but this increase was not statistically significant (see Table XIII).

2. Part II

It was hypothesized that target sets would be verified and corrected quickest and most accurately using the inverse-video format. Analysis showed no significant differences in time, input or output accuracies, and time versus accuracy between the three display formats tested. This was rather suprising. It was originally believed the single-space format would require much more time and induce more errors than the other two methods. There were differences in subject preference among the three display formats. The double-space format was preferred by 65 percent, as compared with 20 percent for the inverse-video and 15 percent for the single-space.

C. RECOMMENDATIONS

Based on the data in Part I it can be concluded that while voice entry is definitely preferred, the IKB is superior in entry speed and input accuracy. Due to limited resources, this thesis had only a discrete voice entry device to measure against an IKB. It is the author's opinion that a conected voice unit would have shown much greater input speeds than the discrete unit used here. Thus, voice applications in areas requiring quick loading of single characters should look toward the continuous voice systems for improvement over conventional keyboard entry devices.

While there was no significant difference among the three display formats, it is suggested that the double-space display format be used. Use of this format would incur no additional cost and would satisfy user preference.

It might be desirable to compare the effectiveness of the three display formats under subject posed and experimenter posed conditions. Thus, the effect of stress could be simulated.

A brief examination of nonrecognitions in Table XIV indicated that the terms Ø, 2, 4, and 5 were more often not recognized than the other numerical terms. A χ^2 was performed on the frequencies observed for the Ø through 9 entries and a χ^2 value of 137.53 was obtained (1Ø df, $P < .\text{ØØ}1$). The Ø through 9 values had been drawn from a table of random numbers, thus each had an equal probability of being misrecognized. The data suggests that the entries Ø, 2, 4, and 5 are over-represented while the entries 9 and 3 are under-represented.

APPENDIX A

T600 VOCABULARY LIST

T600 Location Register	T600 Output
000	zero
001	one
002	two
003	three
004	four
005	five
006	six
007	seven
008	eight
009	nine
010	control
011	modify
012	enter
013	yes
014	no
015	alfa
016	bravo
017	charlie
018	left
019	right

APPENDIX B

SCRIPT & INSTRUCTIONS TO SUBJECTS

1) The CRT and the integrated keyboard (IKB) you see here are similiar to those found at the navigator's position in the B-52G. I will be measuring your ability to load target information in actual ALCM formats using keyboard and voice entry. The experiment is divided into two parts. Part I will require you to load 20 ALCM target sets using both the IKB and voice entry. Part II will require you to call up each of six ALCM target sets I have preloaded, and make corrections to them if necessary with new values you will have in front of you. This will be done three times, each with a different CRT display format.

2) Show photos (Figures 3,4) of navigator's position in B-52G. Show actual IKB (Figure 5) and the working model used in experiment (Figure 6).

3) If the voice unit is used first, train the 20 vocabulary words at this time. Explain the theory of voice entry. After words have been trained, have subject repeat each three times, confirming the voice unit can understand at least two out of the three utterances. For each word failing the above test, have subject retrain that word.

4) Show subject typical ALCM target sets. Run practice computer program. Show subject how to call up, enter, modify, etc., target sets.

You have as much time as you feel is necessary to practice. When you feel comfortable with the procedure, we will proceed with Part I of the experiment.

(Answer any questions and assist if necessary.)

5) You will be given 20 ALCM target sets printed on 3 sheets of paper. When I say, "ready, begin", enter the sets as fast as possible while maintaining accurate inputs. If you make a mistake, be sure to correct it.

Any questions? Ready, begin.

6) Repeat above paragraphs (4) and (5) using other entry method, after subject completes a ten minute break.

7) We will now begin Part II of the experiment. I have preloaded 18 ALCM target sets in three groups of six. You will be given each set of these six target sets separately on a sheet of paper with some of the values changed. You will be required to display each target set on the CRT, compare it to the corresponding target set on the paper, and make the necessary corrections to the target set on the CRT. Some target sets will require no corrections, while others will require many. Each group of six target sets will be displayed on the CRT in one of three ways: single- spaced, double-spaced, or inverse-video.

Show subject example of ALCM target sets with changed values on a sheet of paper. Run practice computer program. Allow subject to practice until he is comfortable with the procedure.

You have as much time as you feel is necessary to practice. When you feel comfortable with the procedure, we will proceed with Part II of the experiment.

(Answer any questions and assist if necessary.)

8) Repeat item #7 if subject fails to understand Part II of the experiment.

If you make a mistake, be sure to correct it.

Any questions? Ready, begin.

9) Repeat above paragraphs (7) and (8) using other entry method.

APPENDIX C

EXPERIMENTAL ORDER FOR SUBJECTS

SUBJECTS 1,3,5,7,9,11,13,15,17,19 performed Part II of the experiment in the following order:

Target Loading Task - Voice,Keyboard

SUBJECTS 2,4,6,8,10,12,14,16,18,20 performed Part II of the experiment in the following order:

Target Loading Task - Keyboard,Voice

SUBJECTS 1,2,3,5,8,7,9,11,13 performed Part II of the experiment in the following order:

Target Information Verification Task -
Single-Spaced, Double-Spaced, Inverse-Video

SUBJECTS 15,17,19,4,6 performed Part II of the experiment in the following order:

Target Information Verification Task -
Double-Spaced, Inverse-Video, Single-Spaced

SUBJECTS 10,12,14,16,18,20 performed Part II of the experiment in the following order:

Target Information Verification Task -
Inverse-Video, Single-Spaced, Double-Spaced

Note: All twenty subjects performed first Part I, "Target Loading Task". This was followed by Part II, "Target Information Verification Task".

APPENDIX D

SUBJECT DATA SHEETS

TARGET LOADING TASK DATA SHEET

NAME: ________________ RANK: ________________

DATE: ________________ SERVICE: ____________

ACCURACY

IAT ________

OAT ________

IAV ________

OAV ________

VOICE or KEYBOARD

NME = NMC ________

NCE ________

TNE ________

% Correct Entries: _____

TARGET LOADING TASK DATA SHEET

CIRCLE ONE: VOICE KEYBOARD

WEA.#	NIC	NMC NME	TIME min.	NICE	NEUTCE line#	#entries
A1				M N		
A2				M N		
A3				M N		
A4				M N		
A5				M N		
A6				M N		
B1				M N		
B2				M N		
B3				M N		
B4				M N		
B5				M N		
B6				M N		
B7				M N		
B8				M N		

TARGET LOADING TASK DATA SHEET (cont.)

CIRCLE ONE: VOICE KEYBOARD

WEA.#	NIC	NMC NME	TIME min.	NICE	NEUTCE line#	NEUTCE #entries
C1				M N		
C2				M N		
C3				M N		
C4				M N		
C5				M N		
C6				M N		

TARGET INFORMATION VERIFICATION DATA SHEET

CIRCLE ONE: SINGLE-SPACED DOUBLE-SPACED INVERSE-VIDEO

ACCURACY

IAT ________

OAT ________

KEYBOARD

NME = NMC ________

NCE ________

TNE ________

% Correct Entries: _____

TARGET INFORMATION VERIFICATION DATA SHEET

WEA.#	# Incorrect Char. to be changed out	NIC	TIME min.	NICE	NEUTCE
A1	6				
A2	3				
A3	8				
A4	3				
A5	6				
A6	0				
B1	3				
B2	4				
B3	9				
B4	4				
B5	3				
B6	3				
B7	9				
B8	5				

TARGET INFORMATION VERIFICATION DATA SHEET (cont.)

WEA.#	# Incorrect Char. to be changed out	NIC	TIME min.	NICE	NEUTCE
C1	Ø				
C2	6				
C3	1				
C4	5				

APPENDIX E

TARGET LOADING TASK INPUT DATA LIST

WEAPON A1 : 1 N31864725
2 E467214Ø85
3 196543Ø873
4 97Ø31687439
5 61498

WEAPON A2 : 1 N19857435
2 E973687525
3 121Ø934753
4 532723610Ø71
5 4Ø912

WEAPON A3 : 1 N5687213Ø
2 E12Ø957264
3 1295725482
4 Ø7362756364
5 28158

WEAPON A4 : 1 N82659374
2 E598326188
3 3871946572
4 283866108Ø64
5 18452

WEAPON A5 : 1 N1Ø725497
2 E728552547
3 185Ø724572
4 75189473575
5 26836

WEAPON A6 : 1 N165ØØ364
2 E86Ø375724
3 Ø734712641
4 184Ø6437553
5 65838

WEAPON B1 : 1 N17896354
2 E194653853
3 5481937906
4 64868351041
5 86357

WEAPON B2 : 1 N52849654
2 E107452749
3 1075382657
4 63956272651
5 20756

WEAPON B3 : 1 N13474638
2 E385638361
3 6120346246
4 01852954752
5 65820

WEAPON B4 : 1 N01472863
2 E184644278
3 1038565275
4 07452865375
5 15832

WEAPON B5 : 1 N86612086
2 E681902642
3 1943028474
4 02857918491
5 65821

WEAPON B6 : 1 N10238475
2 E027361856
3 7453298136
4 08164829154
5 68264

WEAPON B7 : 1 N02746382
2 E578103856
3 5482107462
4 10825483217
5 62741

```
WEAPON B8 :  1 N58286108
             2 E193656828
             3 1037561937
             4 18401746218
             5 51073

WEAPON C1 :  1 N10354826
             2 E102462651
             3 6295016472
             4 39741845226
             5 10275

WEAPON C2 :  1 N17494625
             2 E629575107
             3 4610374628
             4 10817381561
             5 19565

WEAPON C3 :  1 N56194015
             2 E452808462
             3 9108265726
             4 51072658254
             5 75382

WEAPON C4 :  1 N01735473
             2 E107562743
             3 1658264634
             4 51956271064
             5 61028

WEAPON C5 :  1 N10741970
             2 E963557254
             3 5629601652
             4 51036582514
             5 62814

WEAPON C6 :  1 N86952753
             2 E106385672
             3 1653903647
             4 01758265781
             5 01538
```

APPENDIX F

TARGET INFORMATION VERIFICATION TASK

PRELOADED TARGET SETS

Summary of #characters/line to be changed out:

Seven hundred seventy-four total characters are possible to be changed out in all 18 target sets. A value of 10% was chosen to be changed out by each subject. Ten percent of 774 = 78, the number chosen to be changed out.

All eighteen target sets were divided into three groups of six target sets/display method. Each of the three groups had 26 characters to be changed out. Characters to be changed out were selected randomly.

		#Characters/line to be changed out:
WEAPON A1 :	1 N02746382	5
	2 E578103856	0
	3 5482107462	1
	4 10825483217	0
	5 62741	0
WEAPON A2 :	1 N10354826	1
	2 E102462651	1
	3 6295016472	0
	4 39741845226	1
	5 10275	0

		#Characters/line to be changed out:
WEAPON A3 :	1 N82659374	0
	2 E598326188	5
	3 3871946572	3
	4 28386610864	0
	5 18452	0
WEAPON A4 :	1 N31864725	0
	2 E467214085	0
	3 1965430873	1
	4 97031687439	2
	5 61498	0
WEAPON A5 :	1 N13474638	1
	2 E385638361	2
	3 6120346246	1
	4 01852954752	1
	5 65820	1
WEAPON A6 :	1 N01472863	0
	2 E184644278	0
	3 1038565275	0
	4 07452865375	0
	5 15832	0
WEAPON B1 :	1 N17494625	1
	2 E629575107	0
	3 4610374628	2
	4 10817381561	0
	5 19565	0
WEAPON B2 :	1 N56872130	1
	2 E120957264	2
	3 1295725482	0
	4 07362756364	1
	5 28158	0

		#Characters/line to be changed out:
WEAPON B3 :	1 N10238475	2
	2 E027361856	7
	3 7453298136	0
	4 08164829154	0
	5 68264	0
WEAPON B4 :	1 N86952753	0
	2 E106385672	0
	3 1653903647	1
	4 01758265781	1
	5 01538	2
WEAPON B5 :	1 N17494625	1
	2 E629575107	0
	3 4610374628	2
	4 10817381561	0
	5 19565	0
WEAPON B6 :	1 N19857435	3
	2 E973687525	0
	3 1210934753	0
	4 53272361071	0
	5 40912	0
WEAPON B7 :	1 N17896354	1
	2 E194653853	6
	3 5481937906	2
	4 64868351041	0
	5 86357	0
WEAPON B8 :	1 N58286108	4
	2 E193656828	1
	3 1037561937	0
	4 18401746218	0
	5 51073	0

			#Characters/line to be changed out:
WEAPON C1 :	1	NØ1472863	Ø
	2	E184644278	Ø
	3	1Ø38565275	Ø
	4	Ø7452865375	Ø
	5	15832	Ø
WEAPON C2 :	1	N1Ø725497	2
	2	E728552547	1
	3	185Ø724572	Ø
	4	75189473575	Ø
	5	26836	3
WEAPON C3 :	1	N52849654	Ø
	2	E1Ø7452749	1
	3	1Ø75382657	Ø
	4	63956272651	Ø
	5	2Ø756	Ø
WEAPON C4 :	1	N56194Ø15	Ø
	2	E4528Ø8462	2
	3	91Ø8265726	Ø
	4	51Ø72658254	Ø
	5	75382	3

APPENDIX G

REVISED TARGET SETS TO BE UPDATED IN PART II

TARGET INFORMATION VERIFICATION TASK

SINGLE-SPACED DISPLAY FORMAT

WEAPON A1 : 1 N07342394
2 E578103656
3 5082107462
4 10825483217
5 62741

WEAPON A2 : 1 N10254826
2 E102462671
3 6295016472
4 09741845226
5 10275

WEAPON A3 : 1 N82659374
2 E758826381
3 3773946571
4 28386610864
5 18452

WEAPON A4 : 1 N31864725
2 E467214085
3 1965430473
4 92001687439
5 61498

WEAPON A5 : 1 N13404638
2 E185638371
3 6160346246
4 01852854752
5 35820

WEAPON A6 : 1 N01472863
2 E184644278
3 1038565275
4 07452865375
5 15832

DOUBLE-SPACED DISPLAY FORMAT

```
WEAPON B1 :  1 N17694625
             2 E629575107
             3 4610375678
             4 10817381561
             5 19565

WEAPON B2 :  1 N56872630
             2 E022957264
             3 1295725482
             4 07362756314
             5 26158

WEAPON B3 :  1 N16238375
             2 E175340833
             3 7453298136
             4 08164829154
             5 68264

WEAPON B4 :  1 N86952753
             2 E106385672
             3 1253903647
             4 01758265081
             5 21548

WEAPON B5 :  1 N17694625
             2 E629575107
             3 4610375678
             4 10817381561
             5 19565

WEAPON B6 :  1 N15867495
             2 E973687525
             3 1210934753
             4 53272361071
             5 40912
```

INVERSE-VIDEO DISPLAY FORMAT

```
WEAPON B7 :  1 N77896354
             2 E990353146
             3 5421937106
             4 64868351041
             5 86357

WEAPON B8 :  1 N57486001
             2 E196656828
             3 1037561937
             4 18401746218
             5 51073

WEAPON C1 :  1 N01472863
             2 E184644278
             3 1038565275
             4 07452865375
             5 15832

WEAPON C2 :  1 N17724497
             2 E828552547
             3 1850724572
             4 75189473575
             5 29637

WEAPON C3 :  1 N52849654
             2 E109452749
             3 1075382657
             4 63956272651
             5 20756

WEAPON C4 :  1 N56194015
             2 E852808461
             3 9108265726
             4 51072658254
             5 77689
```

APPENDIX B

EXPERIMENTAL DATA

TABLE VIII

SUBJECT ERRORS - TARGET LOADING TASK

(IKB)

SUB.#	NIC	NEC	NICE	NMC	NCE	TNE	% CORRECT ENTR.
1	0	9	9	2	1351	1381	%97.6
2	0	44	0	0	1316	1448	%90.9
3	0	6	6	1	1354	1378	%98.2
4	46	5	51	46	1309	1375	%91.9
5	0	8	8	0	1352	1444	%93.6
6	3	7	10	3	1350	1376	%97.9
7	0	6	6	0	1354	1371	%98.8
8	43	2	45	45	1315	1366	%93.2
9	2	10	12	27	1348	1399	%94.5
10	5	5	10	0	1350	1386	%97.4
11	0	1	1	0	1359	1362	%99.8
12	47	5	62	90	1298	1374	%88.7
13	0	4	4	0	1356	1368	%99.1
14	2	3	5	0	1355	1394	%97.2
15	0	22	22	0	1338	1438	%93.0
16	36	17	53	46	1307	1390	%91.0
17	0	1	1	0	1359	1362	%98.8
18	1	6	7	0	1353	1381	%98.0
19	19	8	27	17	1333	1389	%94.8
20	0	8	8	0	1352	1383	%97.8

LEGEND:
- NIC: Number Incorrect Characters
- NEC: Number Entries Corrected
- NICE: Number of Incorrect Entries = NIC + NEC
- NMC: Number Missing Characters (same as NME)
- NCE: Number Correct Entries
- TNE: Total Number Errors

TABLE IX

SUBJECT ERRORS: TARGET LOADING TASK

(VOICE)

SUB.#	NIC	NEC	NICE	NMC	NCE	TNE	% CORRECT ENTR.
1	1	4	39	0	1321	1368	%99.0
2	2	19	60	7	1320	1412	%91.6
3	1	17	74	0	1286	1413	%91.0
4	4	7	49	2	1311	1398	%93.6
5	3	21	73	3	1287	1442	%89.0
6	8	8	47	7	1313	1392	%93.9
7	3	29	50	0	1310	1420	%92.3
8	1	10	32	45	1349	1408	%92.8
9	0	17	81	2	1279	1430	%89.3
10	4	23	51	0	1309	1440	%90.9
*11	1	21	81	0	1279	1418	%90.2
12	0	18	44	0	1316	1399	%94.1
*13	6	8	41	45	1319	1378	%92.7
14	1	5	22	0	1338	1392	%96.1
*15	7	43	89	10	1271	1449	%87.1
16	9	17	108	0	1252	1444	%86.7
*17	3	27	118	0	1242	1436	%86.5
18	5	16	41	10	1319	1400	%93.5
*19	1	9	35	0	1325	1391	%95.3
20	14	38	110	9	1250	1449	%85.7

LEGEND: NIC: Number Incorrect Characters
NEC: Number Entries Corrected
NICE: Number of Incorrect Entries = NIC + NEC
NMC: Number Missing Characters (same as NME)
NCE: Number Correct Entries
TNE: Total Number Errors
* : Previous Experience with Voice Input

(The voice portion of NICE also includes the number of voice unit nonrecognitions and missrecognitions)

TABLE X

SUBJECT ERRORS: TARGET INFORMATION VERIFICATION TASK

(SINGLE-SPACED FORMAT)

SUB.#	NIC	NEC	NICE	NMC	NCE	TNE	% CORRECT ENTR.
1	5	0	5	1	125	130	%95.4
2	0	0	0	0	130	130	%100.0
3	0	0	0	1	130	132	%97.7
4	0	0	0	0	130	130	%100.0
5	4	1	5	0	117	130	%90.0
6	0	0	1	1	129	130	%98.5
7	0	0	0	0	130	132	%98.5
8	1	0	1	0	129	130	%92.3
9	0	0	0	0	130	130	%100.0
10	0	1	1	0	129	132	%97.7
11	0	6	6	1	124	145	%84.9
12	0	0	0	0	130	130	%100.0
13	0	1	1	0	129	132	%97.7
14	4	1	5	0	125	132	%94.7
15	0	3	3	0	127	150	%84.6
16	0	1	1	1	129	138	%92.8
17	2	2	4	0	126	132	%95.5
18	0	0	0	0	130	130	%100.0
19	0	0	0	0	120	132	%98.5
20	1	0	1	1	129	130	%98.5

LEGEND: NIC: Number Incorrect Characters
NEC: Number Entries Corrected
NICE: Number of Incorrect Entries = NIC + NEC
NMC: Number Missing Characters (same as NME)
NCE: Number Correct Entries
TNE: Total Number Errors

TABLE XI

SUBJECT ERRORS: TARGET INFORMATION VERIFICATION TASK

(DOUBLE-SPACED FORMAT)

SUB.#	NIC	NEC	NICE	NMC	NCE	TNE	% CORRECT ENTR.
1	0	4	4	1	128	141	%99.1
2	0	0	0	0	132	136	%97.1
3	1	5	6	0	126	141	%89.4
4	5	0	5	0	127	132	%96.2
5	0	0	0	0	132	132	%100.0
6	2	1	3	0	129	134	%96.3
7	0	1	1	0	131	134	%97.8
8	1	0	1	0	131	134	%96.3
9	1	3	4	0	128	138	%92.8
10	1	1	2	1	130	134	%96.3
11	0	1	1	1	131	134	%97.0
12	0	3	3	0	129	134	%96.3
13	1	1	2	1	130	138	%93.5
14	3	1	4	1	128	144	%88.3
15	0	1	1	1	131	137	%94.9
16	1	4	5	2	127	140	%89.4
17	0	3	3	1	129	147	%87.2
18	1	3	4	0	128	137	%93.4
19	1	2	3	0	129	136	%94.9
20	0	3	3	0	129	138	%93.5

LEGEND:
NIC: Number Incorrect Characters
NEC: Number Entries Corrected
NICE: Number of Incorrect Entries = NIC + NEC
NMC: Number Missing Characters (same as NME)
NCE: Number Correct Entries
TNE: Total Number Errors

TABLE XII

SUBJECT ERRORS: TARGET INFORMATION VERIFICATION TASK

(INVERSE-VIDEO FORMAT)

SUB.#	NIC	NEC	NICE	NMC	NCE	TNE	% CORRECT ENTR.
1	0	0	0	0	115	115	%100.0
2	0	0	0	0	115	121	%95.0
3	0	0	0	0	115	115	%100.0
4	0	0	0	3	115	115	%97.5
5	7	0	7	0	108	115	%93.9
6	0	0	0	2	115	115	%98.3
7	0	1	1	0	114	125	%91.2
8	0	0	0	0	115	115	%100.0
9	0	1	0	0	114	117	%97.4
10	0	2	2	0	113	119	%95.0
11	18	0	18	0	97	115	%84.3
12	5	2	7	0	108	115	%93.9
13	0	7	7	0	108	121	%89.3
14	3	1	4	1	111	127	%86.7
15	0	0	0	0	115	118	%97.5
16	9	3	12	1	103	124	%82.4
17	2	0	2	0	113	115	%98.3
18	0	0	0	0	115	115	%100.0
19	1	2	3	0	112	120	%93.3
20	1	0	1	0	114	115	%99.1

LEGEND:
- NIC: Number Incorrect Characters
- NEC: Number Entries Corrected
- NICE: Number of Incorrect Entries = NIC + NEC
- NMC: Number Missing Characters (same as NME)
- NCE: Number Correct Entries
- TNE: Total Number Errors

TABLE XIII

ERRORS* DURING VOICE ENTRY

SUB.#	TARGET SETS				TOTAL
	1-5	6-10	11-15	16-20	
1	6	6	16	10	38
2	17	19	23	9	68
3	14	26	21	11	72
4	7	12	13	13	45
5	19	18	18	15	70
6	9	11	8	9	37
7	12	11	6	6	9
8	7	9	6	7	29
9	13	18	24	26	81
10	16	7	10	13	46
11	12	18	15	14	59
12	11	9	6	9	35
13	12	3	11	7	33
14	4	4	2	7	17
15	13	6	7	13	39
16	6	29	28	17	60
17	17	17	28	26	88
18	3	2	6	9	20
19	6	9	7	3	25
20	10	10	5	23	48
mean:	10.7	12.5	12.7	13.0	
sd:	4.6	7.6	7.8	6.3	

* Nonrecognitions and Misrecognitions

TABLE XIV

NONRECOGNITIONS OF UTTERANCES BY ENTRY

ENTRY	TOTAL NONRECOGNITIONS
0	92
1	49
2	86
3	31
4	107
5	82
6	44
7	32
8	40
9	24
control	32
modify	19
enter	59
yes	4
alpha	6
bravo	16
charlie	0
left	17
right	32

TABLE XV

NONRECOGNITIONS OF UTTERANCES BY SUBJECT

SUB.:	TOTAL NONRECOGNITIONS
1	34
2	39
3	53
4	36
5	48
6	23
7	18
8	18
9	63
10	20
11	53
12	23
13	27
14	15
15	39
16	81
17	80
18	20
19	25
20	58

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